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DEFENSE COMMUNICATIONS AGENCY

PLANNER'S GUIDE TO FACILITIES LAYOUT AND DESIGN FOR THE DEFENSE COMMUNICATIONS SYSTEM PHYSICAL PLANT

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VOLUME 1A

DCS TRANSMISSION FACILITIES

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DEPARTMENT OF DEFENSE
UNITED STATES OF AMERICA

DEFENSE COMMUNICATIONS AGENCY
WASHINGTON, D. C. 20305

DCA CIRCULAR 300-95-1

29 July 1985

DCA FACILITIES

A Planner's Guide to Facilities Layout and Design for the Defense Communications System Physical Plant

1. Purpose. This Circular provides planning information, guidance, and criteria for the development of facility renovation, expansion, alteration, or new construction projects planned for the worldwide DCS physical plant.

2. Applicability. This Circular applies to Headquarters, DCA; DCA field activities; and military departments responsible for the planning and acquisition of DCS facilities.

3. Contents. To facilitiate the use, updating, and expansion of the material covered, the Circular has been organized into three general divisions.

a. Volumes 1a and 1b provide the bulk of the information neccesary to plan specific DCS facility types. All of the theoretically ideal data which needs to be considered at any of the stages of project development is contained in these first two volumes.

b. Volume 2 contains generic information which may additionally apply to specific facilities, depending on their location and importance within the DCS.

c. Volume 3 provides a series of case studies to demonstrate ways of applying the "ideal" guidance contained in the first three volumes with the practical limitations of the world in which the DCS must plan and operate.

4. Document Improvement. This is intended to be a living document, one which will mature with the evolution of the DCS. To accomplish this goal, comments or suggestions for improvement of the contents are encouraged, and should be directed to the Defense Communications Agency, ATTN: Code B212, Washington, D. C. 20305.

FOR THE DIRECTOR:

DARLENE K. BREWER
Colonel, USAF
Chief of Staff

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FOREWORD

This investigation was performed by the Facility Systems Division (FS), of the U.S. Army Construction Engineering Research Laboratory (USA-CERL), Interstate Research Park, P.O. Box 4005, Champaign, IL 61820, for the Defense Communication Agency under Order No. HC 1001-2-40152.

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TERMS, ABBREVIATIONS, AND ACRONYMS

ADPE	Automated data processing equipment
A-E	Architect-engineer
AFASPO	Air Force Automated Systems Project Office
AFCC	Air Force Communications Command
AFCCPC	Air Force Communications Computer Programming Center
AFDSEC	Air Force Data Systems Evaluation Center
AFLC	Air Force Logistics Command
AFM	Air Force Manual
AFP	Air Force Pamphlet
AFR	Air Force Regulation
AFOTEC	Air Force Operational Test and Evaluation Center
AMPE	Automated Message Processing Exchange
ANSI	American National Standards Institute
ASC	AUTODIN Switching Center
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
ATC	Air Training Command
AUTODIN	Automatic Digital Network
BLACKER	Telecommunications encryption device
BOD	Biochemical oxygen demand
C-E	Communications-electronic
C-E-M	Communications-electronics-meteorological
CBR	Chemical, biological, radiological
COE	Corps of Engineers
COMSEC	Communications Security
CONUS	Continental United States
CSCE	Communications system control element
DCA	Defense Communications Agency
DCEC	Defense Communications Engineering Center
DCS	Defense Communications System
DDN	Defense Data Network
DIA	Defense Intelligence Agency
DLA	Defense Logistics Agency
DOD	Department of Defense
DODD	Department of Defense Directive
DODI	Department of Defense Instruction
DRAMA	Digital Radio and Multiplexing Acquisition
DSSCS	Defense Special Security Communications System
EHF	Extra-high frequency
EIC	Engineering Installation Center
EPA	Environmental Protection Agency
ESC	Electronic Security Command
ESD	Electronic Systems Division
ETS	European Telephone System
FY	Fiscal year
GENSER	General service
GFE	Government furnished equipment
GSA	General Services Administration
HEMP	High-altitude electromagnetic pulse
HF	High frequency
HVAC	Heating, ventilation, and air-conditioning
IAS	Integrated AUTODIN System

IASA	Integrated AUTODIN System Architecture
IAW	In accordance with
I/C	Installation/cutover
IOC	Initial operational capability
I-S/A	Inter-service/agency
ITSTEC	Integrated Transmission, Switching and Technical Control
JCS	Joint Chiefs of Staff
JRSC	Jam-resistant satellite communications
LCC	Life cycle cost
LCCE	Life cycle cost estimate
LMD	Lead Military Department
LSI	Large-scale integration
LSTDM	Low-speed time division multiplexer
MAJCOM	Major Command
MCP	Military Construction Program
MILDEP	Military Departments, Army/Navy/Air Force
NAVFACENGCOM	Naval Facilities Engineering Command
NCC	Network Control Center
NSA	National Security Agency
OCONUS	Outside Continental United States
OCR	Office of Collateral Responsibility
O&M	Operations and maintenance
O&M COMMAND	Service/Agency Responsible for Funding O&M Costs
OICC	Officer in Charge of Construction
OJCS	Organization of the Joint Chiefs of Staff
OPR	Office of Primary Responsibility
OSD	Office of the Secretary of Defense
POM	Program Objective Memorandum
PSN	Packet switching node
RFI	Radio frequency interference
RTAC	Real-time adaptive control
SAF	Secretary of the Air Force
SCI	Sensitive compartmented information
SECDEF	Secretary of Defense
SS	Suspended solids
SOP	Standard operating procedures
SOW	Statement of work
SSMA	Spread spectrum multiple access
SVIP	Secure Voice Improvement Program
TCIP	Technical Control Improvement Program
TEMPEST	Compromising electromagnetic emanations
UPS	Uninterruptable Power Supply
USA	United States Army
USMC	United States Marine Corps
WWOL	Worldwide on-line system

INTRODUCTION

1 Purpose of These Documents

The Military Departments (MILDEPs) operate Defense Communication System (DCS) facilities throughout the United States and the free world. These facilities must provide a high level of mission responsiveness to enhance the specific activity efforts of military service personnel. Also, since DCS requirements and communication equipment are constantly evolving, much flexibility must be designed into each facility.

The Defense Communications Agency Defense Communications Engineering Command (DCA/DCEC) desired to implement an optimal workstation and facility layout design handbook to assist planning, programming, and design personnel in increasing the environmental satisfaction of all DCS facility users. To this end, the U.S. Army Construction Engineering Research Laboratory (USA-CERL) was requested to survey, evaluate, and design prototype optimal workstations and total facility layouts for all personnel and equipment requirements. The objective of this effort was to develop optimal prototype space utilization and habitability designs for all DCS facility types. A research plan was started to: (1) determine all generic communication areas and space requirements, (2) analyze the mission responsiveness issues (efficiency, privacy, security, etc.) for the various workstations, (3) design an optimal layout plan for each space type, and (4) provide planning, programming, and design documents to assist in the development of all future projects. These documents would aid in designing new construction and in renovating existing buildings to meet current accepted requirements for the DCS facilities.

The handbook has been separated into three volumes, 1A, 1B, and 2. Volumes 1A and 1B contain facility information obtained from personnel who operate and maintain the DCS. Using input from several (7 to 16) persons about the same space, generic requirements necessary to accomplish the DCS activities in that space were determined. Therefore, Volumes 1A and 1B contain mostly new information from persons with several years' actual experience in a variety of existing DCS facilities and circumstances. Volume 1A has information about each space of each transmission facility type and Volume 1B has similar information about the spaces in switch and control facilities. Volume 2 contains information about extenuating conditions that also must be considered as part of the requirements for responsive DCS facilities--survivability, security, climate, construction components, site utilities, and similar factors. Most Volume 2 information came from existing documents (approximately 200) approved for use in DCS facility planning, programming, and design. All extracts from these documents are identified by a number at the end indicating the document and the page or section from which the extract was taken, e.g., "(9) 153" indicates that the extract came from page 153 of the source numbered 9 in the Bibliography.

These documents are designed to serve many types of facility project decision makers. Specifically, they are intended to aid facility planners, programmers, and construction project designers; they also should help DCS facility commanders to evaluate their existing facilities. These users require several types of facility information. Thus, information in this handbook can be used for specific design decisions for new construction or renovation, and for evaluation of an existing facility. For the first type of decision, once a communication requirement has been determined, these documents have the information required to determine the total area and separate spaces for operational sections in each major organizational unit. Next, optimal room areas are indicated to assist in dividing up the allocated square footage of each organizational unit. Finally, the individual workstations can be designed considering the demands on communications, electrical, and mechanical systems. For the second type of decision, this information is intended to allow DCS facility commanders to develop a continuing evaluation program for their facilities. The information is in a format that describes optimal workstation requirements, criteria, and guidance layouts; individual units can work toward these in a series of small-scale operations and maintenance improvement projects to improve the total facility operational effectiveness in performing the DCS mission.

These documents also provide DCS facility site planning concepts. The Department of Defense (DOD), DCA, and MILDEP communication command personnel can use this information to determine construction and/or equipment procurement needed to carry out the total communication mission. Readers interested in developing functional requirements for the 1391 documentation of a construction project should focus primarily on activity, personnel, equipment, and requirements columns for each space and on the space relationship diagram for each facility type. Readers interested in developing project designs should attend to the criteria, guidance, building components, and systems columns for each space and to the prototype total building design at the end of each facility type section.

2 Organization of the Information

The information in these documents is organized into data that apply to the following:

a. Individual workspaces within organizational subsections of a communication facility.

b. An entire DCS facility as an integrated whole.

c. Recommendations for options to accommodate the special operational and survivability requirements for an entire DCS site.

The information is formatted space by space. For each component space, 10 types of data are presented:

1. *function*--statement of the overall reason for the space in a facility.

2. *policy and sop* (standard operating procedures)--regulations that define what must be done and how it should be done. The information is taken from documents such as service regulations, field manuals, and unit or installation procedure statements.

3. *issues*--data indicating how the work activities can be improved by alternative environmental conditions or trade-offs related to different ways of accomplishing functions at the facility.

4. *assumptions*--statements related to each issue; these recommend how the facility should be designed for optimal mission responsiveness over time. (Not all issues have these recommendations.)

5. *activities/personnel/equipment*--specifically what the functional operations are, who does them, and with what equipment that is not part of the building.

6. *requirements*--qualitative statements about what the building must be to provide optimal occupant/environmental interaction over time.

7. *criteria*--statements developed directly from the requirements list; these provide quantitative and/or qualitative measures to determine the proper design solution for an interactive building.

8. *guidance*--statements, sketches, and diagrams providing realistic advice based on design experience and case studies related to similar building spaces.

For each DCS facility type, a space relationship diagram is also presented to show the desired optimal adjacencies of all workstations and spaces for the particular facility. All information contained in the 10 categories is generic and relates to functions at DCS communication facilities. "Generic" means these functions are generally operational for any communication facility, no matter which military unit is involved. In progression, the separate spaces first were generated in terms of relating policies and SOP to the activities, personnel, and equipment required to accomplish a specific function. Next, requirements and criteria for the facility workstations were developed. Finally, planning concepts in the form of potential guidance related to specific building or exterior operational areas were generated. Thus, the requirements, criteria, and guidance provide the "optimal information" for mission activities. Relevant information about operation and maintenance (O&M) practices were obtained from discussions with military units, communication industry operators, construction researchers, and reviews of current periodicals and research literature. The information has been integrated into a six-page format for each functional area so that all information can be seen together, starting with the policies related to a particular function through space layout sketches and building component and systems recommendations. This organization should permit ready access and easy incorporation of applicable information into planning, programming, and design documentation by the various decision makers who develop DCS facilities.

3 Future Development of the DCS

As DCS changes to meet future demands, the transition will reflect an evolution toward current technology and concepts as well as increased commonality with civil systems and improved interoperability with other communications agencies. This theme is dictated by DOD's evolutionary acquisition system and by the economic realities of constrained DCS budgets. The constant need for expanded services demands that the design approach retain flexibility to improve as opportunities permit, yet competition for monetary resources insists on greater cost efficiency. Thus, there will be a need for balance as well as for facilities that support the evolutionary systems. (182) B-1

The main reasons for changing the baseline facilities are (1) deficiencies in the quality and reliability of power, (2) energy inefficiency, (3) lack of facility standardization, and (4) possible vulnerability to sabotage and EMP effects. Energy use at the DCS sites will continue to escalate the total cost to DCS. Power system improvements and power-saving steps can reduce energy expenditures, leading to many benefits in availability and reliability. Changes in DCS communications equipment will permit real gains within the total communications complex. With the size of equipment and power consumption reduced, new approaches to facilities and facility support become possible. Areas other than power, such as environmental control and building size, can be demanding with respect to heating/cooling requirements. Also, spectronics and facilities equipment can be designed on a system basis to take advantage of individual system characteristics. (182) B-2

DCS facilities thus will evolve in different aspects during future development. Several trends will be evident in this transition, as summarized below.

Transmission Media

Programs are available to change much of the DCS transmission media to digital techniques using a mix of media nodes. Pulse code modulation will provide the initial digital transition. Submultiplexers are programmed to replace old voice-frequency carrier telegraph equipment, and these will combine low-speed data input into a composite higher bit stream suitable for interfacing with 64 kbps data. Other time-division multiplexers are also being developed to support the digital DCS; bulk encryption is being developed for wideband links. Initially, wideband circuits between CONUS and overseas gateway stations will be encrypted, followed by encryption of the more critical overseas trunks. Commercially leased bandwidth will be bulk-encrypted at Government-owned technical control gateway facilities.

Early conversion from analog to digital transmission is a primary planning objective for DCS links because digital systems offer improved security performance, lower O&M costs, and pacing factors due to commercial, tactical, and data processing trends. Most terrestrial systems will be converted to digital ones by FY92, leading to bulk encryption, unstaffed stations, fewer modems, and simple interfaces to circuit switches. High frequency (HF) systems will be improved using adaptive techniques and new modems for digital operation. Economics will determine the timing of commercial terrestrial systems being digitized, but the long-term trend is toward digital transmission.

Wartime stress threats provide strong motivation for improved DCS connectivity. Interconnects with tactical, allied, and commercial systems thus are being considered to counter wartime conditions. A Joint Military Tactical Satellite System (JMTSS) is being considered to interconnect tactical systems with the DCS and to extend the DCS in wartime. Satellite systems, commercial as well as the Defense Satellite Communication System (DSCS), will be improved. Commercial satellites will offer multiple spot-beam antennas, higher operating radio frequencies, on-board TDMA switching, small earth terminals, and demand access. DSCS will acquire adaptive controls, channelized transponders, multiple-beam antennas, on-board processing, and extra high frequencies (EHF). Commercial systems, with increased commercial competition, will also offer attractive prices and route diversity as alternatives to Government-owned systems. (182) B-3

Satellite Media

Earth terminals served by the DSCS will number more than 600 by 1986. Among these terminals are the heavy, fixed variety and several small, transportable systems that will serve the ground mobile forces and special users such as the Diplomatic Telecommunications Service and the White House Communications Agency.

DSCS III space platforms will be operational in the mid-80s and will feature six transponders per satellite, multibeam antennas, channelized transponders, and adaptive power control. Two of the transponders will have 40-watt traveling wave tube amplifiers and the other four will have 10-watt traveling wave tube amplifiers. Antijam capabilities will become available with the AN/USA-28 modem and a spread spectrum multiple access (SSMA) modem for GMF terminals. The Jam-Resistant Satellite Communications (JRSC) program will field AN/TSC-86 terminals (with AN/USC-28 modems) near worldwide military command and control systems (WWMCCS) users, canceling their dependence on gateway satellite terminals. Higher frequency transponders (in the EHF range) can be expected for DSCS in about 1990.

Leased satellite service for INTELSAT will connect the CONUS to Europe and to the Pacific; DOMSAT will provide satellite service within the Western Hemisphere (Alaska, Caribbean, Hawaii, CONUS). Leased satellite service will offer single- and multichannel, point-to-point, analog, and digital service and will be cost-competitive over distances greater than 1300 kilometers. (182) B-4

Terrestrial Media

Terrestrial transmission systems will be converted from analog to digital type when existing equipment requires replacement or when it is otherwise necessary to convert. Network time synchronization will be applied for digital control. Fiber optic cable will be used to replace wire cable in some local areas as requirements and cost benefits dictate. The Digital Radio and Multiplexing Acquisition (DRAMA) program will provide transmission rates to 26 Mbps and bulk encryption. In the 1980s, a low-speed, time-division multiplexer (LSTDM) will offer user-to-user digital communications in multiples of 32 kbps. Unstaffed repeater stations for transmission systems will become more numerous.

HF radio systems will be retained primarily for restoral and contingency use. Digital HF transmission is expected, possibly to 16 kbps per channel. Since there is no existing plan or program for DCS HF radio advancements, the model for future HF is existing HF installations such as Croughton (Air Force), Pirmasens (Army), and Naples (Navy). The far-term concept is to transform the DCS into a Defense Switched Network (DSN). The DSN will have integrated transmission, switching, and technical controls and will be decentralized (in contrast to the present system) for long-haul communications. The network, above the base and local levels, will treat a whole base and a high density/high population user locale as a terminal. Maximum use will be made of commercially leased services. Separate network facilities and identities for AUTOVON, AUTODIN, and AUTOSEVOCOM will not be possible. The only distinction between voice and data services will be found at the user's terminal. Other concepts that will drive equipment acquisitions are:

1. Digital wideband transmission facilities as more communications satellites are used.
2. Bulk encryption as digitization proceeds.
3. Automation of most media functions as minicomputers and microcomputers become integral components of transmission facilities.
4. Unstaffed facility O&M as automation proceeds.
5. Reduction in the number and size of the largest facilities as a distributed (nodeless) and automated system is implemented.

6. More automatic interconnect opportunities between single transmission media systems (U.S.-commercial-international), and between user terminals and multimedia gateway facilities. (182) B-5

Message and Circuit Switches

Within the DCS switched voice networks, the feasible union of AUTOSEVOCOM and AUTOVON services will be evident as AUTOVON becomes the primary carrier for secure voice services. The trend will first appear in the Secure Voice Improvement Program (SVIP), which will be the vehicle for introducing a secure voice terminal to replace AUTOVON four-wire stations. AUTOVON itself will evolve to exploit developments in commercial telephony. AUTOVON/AUTOSEVOCOM will primarily change to reflect dramatic improvements occurring in commercial digital circuit-switching technology.

Common-user record and data traffic needs for the near term will be met by the AUTODIN I message-switched network. However, by FY92, AUTODIN I will have been merged into the Integrated AUTODIN System (IAS). The IAS is being developed to define a DCS subsystem that satisfies the requirements of AUTODIN I users worldwide in the most cost-efficient way possible. The IAS must be flexible enough to allow increases in system capacity and the addition of new capabilities, should such changes be justified by developing requirements. It will ultimately be fully integrated and engineered on a terminal-to-terminal basis.

Although the near- and midterm DCS architectures provide for independent switching functions through a wide variety of DCS subsystems (AUTOVON, AUTOSEVOCOM, and AUTODIN I), the future DCS will be characterized by distribution of the switching function and integration of DCS subsystems. The capability to switch nonsecure voice currently is provided by AUTOVON, whereas AUTOSEVOCOM provides secure voice switching. Beginning in about 1985, these functions will be merged under the SVIP as described above. Similarly, the IAS is designed to combine the packet switching capabilities with the message data switching capabilities of AUTODIN I. The final integration of functions will occur during the transitional period between 1998 and 2005. The end result of the integration process will be a cost-effective DCS III network supporting distributed communications and a unified signaling structure. AUTOVON, AUTODIN, and AUTOSEVOCOM will no longer be separate DCS subsystems; instead, they will consist of terminal programs served by a distributed DCS III/DSN.

Other plans for the near future include thinning the AUTODIN I switch population, developing a common family of AUTODIN terminals, and completing deployment of the current generation of Automatic Message Processing Equipment (AMPE). AUTODIN I switches will be phased out, and new elements (i.e., Inter-Service/Agency [I-S/A] AMPEs and Centralized Service Facilities) will be fielded. A major objective of the midterm architecture is to preserve continuity of existing network services throughout the transition from old to new equipment. To facilitate this smooth transition, functions unique to AUTODIN I ASCs will be reallocated to new IAS elements; for example, I-S/A AMPEs will be enhanced to include the functions performed by near-term ASCs. The far term will see increased integration of the IAS with other DCS subsystems and continued evolution to an all-digital environment.

Another traffic switching program that could have major implications for the future DCS (overseas) is the European Telephone System (ETS). This system consists of 140 switching centers to be installed during 1983-86 (in Germany, Italy, and the BENELUX nations) to replace the current Direct Distance Dial Network and other common user telephone networks in Europe. The ETS could replace the few AUTOVON switches programmed for retention in DCS Europe. The ETS also could be used as a preprogrammed (logic) switching capability for a completely new communications system concept called the "Integrated Transmission, Switching, and Technical Control" (ITSTEC). (182) B-6

System and Technical Controls

The overall trends toward automation and digitization are also apparent in technical control. The technical control improvement program is to provide more effective ways to control the DCS, especially in a crisis environment. The approach is to improve recovery/reconstitution response time by reducing dependence on manual control procedures and in turn exploiting, when possible, proven operationally oriented automated and semiautomated processor-aided procedures.

Several developments in technology can improve DCS recovery/reconstitution response time. The most important development is incorporation of technology in the DCS switching and transmission subsystems to facilitate subsystem-level controls, thus enabling recovery, reconfiguration, and interoperability. An example is the DSCS, which is evolving with increasing flexibility to dynamically manage and reallocate satellite resources in response to traffic requirements and stress situations. Similar capability to dynamically reallocate terrestrial digital transmission resources is also feasible. A second development is the emergence of the tactical Communications System Control Element (CSCE). The CSCE will provide the communications and processing resources for exchanging and processing timely management and control information throughout the tactical echelons. This system control concept has potential application in the DCS.

The major improvements anticipated for control capabilities during FY83-92 will likely evolve from six major ongoing control programs:

1. Worldwide On-Line (WWOL) system upgrade.
2. DCS System Control Improvement Program.
3. DCS Technical Control Improvement Program (TCIP), both manual and automatic.
4. DCS Voice Orderwire Program.
5. DSCS Real-Time Adaptive Control (RTAC).
6. Establishment of a Network Control Center (NCC) in support of DCS. (182) B-9

Facilities

Facility designers and users will begin taking advantage of new technology aimed at their needs. The evolving DCS baseline will affect the needs for structure size, environmental control and power requirements, and proper grounding, bonding, and shielding.

The move to integrated circuitry by various elements of the DCS will have a profound effect on structures that house DCS elements. First, it will permit consolidation within buildings designed for retention. Although some modification within the structure will be necessary, parts of the building will be filled for other purposes, thereby lowering building maintenance costs. Functional consolidations will permit cross-utilization of manpower, reduce manpower-intensive communications-electronics (C-E) functions, and result in reduced annual DCS O&M costs. The move to smaller electronics will permit the use of smaller sites that are easier to secure and that have a reduced need for external utilities support. Although the next 10 years may see few new DCS sites, extensive modifications will occur at many existing sites. The need to acquire real estate is a major contributor to the utilization of present locations, since in many locales new land acquisition is nearly impossible. There will be a trend to standardize as facilities are built, modified, or leased. These standards will include concepts to increase the structure's flexibility in configuring or adapting to changing requirements. Consistent with efforts to improve the standards and flexibility of DCS structures will be efforts to improve the survivability protection against conventional warfare and EMP threats through the use of innovative construction concepts. These include using earthen covers or adapting standard buildings to DCS sites quickly. For the near- and midterm, the structure, other facilities, and equipment will be adapted and integrated more closely to reduce energy consumption, lower maintenance costs, and rely less on personnel.

As the DCS evolves, power systems that support the communications system will be improved to insure reliability in providing the quality of power required. The cost of commercial power is expected to continue rising, so that the evolving DCS baseline will move toward alternative power sources when possible. The need for back-up power will remain and the rotating engines that provide it will be in the system into the midterm. However, diesel generator use should decline as onsite power becomes more practical using photovoltaic solar panels. At some sites that require large amounts of power, the reliable long-life diesel motor generator may supply the primary power.

By the end of the midterm there will be few exceptions to a total d.c.-powered DCS. This will increase efficiency and reliability by reducing the number of components in the system. It will also improve the DCS' ability to use renewable power sources such as photovoltaic solar panels, wind-powered generators, thermoelectric generators, and other power sources for which the output is generally d.c.

Renewable energy sources may not be practical in all cases. For example, there may be long periods of no sun or wind when a nonrenewable source must carry the load. Since during wartime a particular fuel may not be available, emphasis will be placed on developing and placing in the field systems that can use several different fossil or synthetic-type fuels.

As new facilities are designed or modified there will be more specific adaptation of the power source to the power requirement. The use of integrated circuits will, in general, require less power as will ancillary components such as environmental controls. Also, the practice to oversize the power system to accommodate possible expansion will be discontinued. The net result by the 1990s will be a savings in total power cost, including costs for fuel, commercial power, maintenance, and personnel to operate and maintain the equipment.

The energy crisis and the trend toward use of lower power dissipation electronics using integrated circuits has made it possible to eliminate complicated environmental control systems. The improved electronics can operate at wide ranges of conditions, thereby reducing the need for a tightly controlled air supply and permitting use of outside air. With the environmental controls eased, significant energy savings can be realized.

Integrated circuits permit the use of innovative packaging or building design to assist in environmental control and to lessen demands for energy. An example is the grouping together of high heat dissipation components, eliminating the need to cool an entire area. Environmental controls traditionally have been part of the building but as the DCS evolves, that trend will fade. As the communications complex becomes smaller, the environmental control system can be adapted to the communications equipment. Portions of buildings can be blocked off to insure that only the critical components are subjected to a precise environment, not the entire structure. Providing a determined integration of the environmental control system with the electronics, power system, and building will permit a more efficient operating unit and reduce environmental control failures. (182) B-12

Many DCS sites have inadequate grounding systems or systems in need of repair; however, the need for more attention in this area is recognized to provide better performance and protection against lightning, EMP, and similar phenomena. Improvement is expected to occur naturally as sites are reconfigured with new electronics. There are plans to rework grounding fully on a system basis at every station targeted for major change in electronics during the next 10 years. (182) B-13

Summary

This introduction has summarized the effects of technological opportunities, planned and programmed DCS trends, and nontechnical/nonprogrammatic considerations 10 to 20 years into the future, including the DCS architectural concept ITSTEC with respect to the 1990s DCS requirement for facilities support. First, the waves of modern, complex, and sophisticated C-E equipment on the commercial market, such as powerful microprocessors spawned from large-scale integration (LSI) technology, offer more cost-effective use of switches, concentrators, and multiplexers within the DCS. The fringe benefits that generally accompany microelectronics are improved reliability of hardware, inherent modularity, and reductions in physical size and energy demands. In fact, some electronic switching systems in the Bell System now operate at such low power levels (less than 6 volts and at a few milliamperes) that conditioned power and shielding become stringent facility requirements. Microprocessor technology will be reflected in DCS C-E equipment and in facilities equipment over an extended period of time extending well beyond 1990. This is because the motivation to make basic changes to the DCS must come through very fundamental, strong reasons. To date, the motivation behind DCS assimilation of modern technology is not a need for technology, per se, to fix a broken system but, the need to find ways to provide existing communications at lower annual O&M costs.

Second, driven again by economics and by much activity in the commercial sector, there will be increased installation of satellite ground terminals associated directly with individual (community) access areas (e.g., single bases and large military populations such as those found in the Washington, DC, and Tidewater, VA, areas). A basic satellite architecture will emphasize direct interconnection between access areas and will deemphasize terrestrial connectivity and switching via rigid backbones that are manpower-intensive. Since military use of satellite communications requires the same measure of survivability and resistance to radio signal jamming as required of any other communications media, it is expected that, as an expedient, connectivity between access areas will be affected first through the switched public networks. This arrangement will continue until satellite communications are hardened enough to make the media viable in war time. In either a public or a military satellite network, without benefit of a Government-furnished backbone, a more unified strategic-tactical DOD switched communications system will evolve. A system like this will represent a second generation DCS that involves real-time dynamic allocation of wideband, digitized transmission channels through DCS switching and processing functions within or adjacent to access areas.

These functions have been defined within the ITSTEC conceptual architecture that could be implemented during 1984-94. The significance of the ITSTEC concept to this study of facilities requirements is that an entirely new, different DCS station is suggested that combines DCS functions which, to date, have generally been supported by separate structures, power plants, environmental controls, and G-B-S installations.

The third major condition influencing facilities requirements along new directions is the development of new perspectives concerning the DCS mission. These perspectives are again driven by economic imperatives to obtain the most utility from finite resources. Over the past 16 years, budgetary constraints have reduced the availability of Army and Air Force tactical communications in-theater assets. Consequently, there is now increased dependence on the in-theater DCS to support U.S. combat forces in the initial phases of any conflict overseas. However, the DCS was not originally designed to be a wartime system. Therefore, a major underlying thrust driving new DCS architectures is "design-for-war."

The DCS research and development strategy for "design-for-war" is to configure/harden certain DCS subsystems based on criticality of the DCS users' needs. This strategy was adopted because a composite DCS resistant to all threats is neither technically feasible nor economical. Therefore, improved DCS readiness will be achieved by developing countermeasures against specific threats in specific areas of the world. In Europe, the all-time threat to the DCS is sabotage; the overt hostilities threat is the collateral effect of conventional munitions delivered by aircraft. At the same time, there is a measured approach to DCS wartime readiness and an increasing concern with the annual DCS costs of providing day-to-day peacetime communications. Fossil fuel and manpower are the most inflationary of the annual recurring costs in MILDEP budgets. With a theoretical monetary lid on how much a peacetime DCS is allowed to cost, it has become necessary for DOD, DCA, and the services to find cheaper alternatives to fossil-fueled power and to find less manpower-intensive ways to support DCS O&M responsibilities. (182) B-57

4 Updating DCS Facility Information

The facility information contained in Volumes 1A, 1B, and 2 is intended to be updated every 2 years as requirements for DCS transmission, switch, and control facilities evolve. Three aspects of the DCS have been and will continue to be the basis of the need for dynamic, evolving DCS facilities:

1. The continuing development of communication transmission, switch, and control equipment--especially the expanded use of computer-automated devices to augment existing capabilities.
2. The refinement of alternative energy sources to be more cost-competitive and less vulnerable to existing commercial power with diesel generator standby back-up.
3. The development of improved security and survivability components that will enable existing DCS installations to become less vulnerable to sabotage and attack threats.

As the existing facility information in each edition of Volumes 1A, 1B, and 2 is used for specific projects that are constructed and operated, it is intended that facility evaluations be carried out to provide feedback to the documents. This feedback can be either additions to provide more comprehensive facility information or deletions to eliminate information that becomes outdated. Over time, the volumes can become handbooks of the best current information available.

5 Example Projects--Retrofits and New Construction Case Studies (Volume 3)

As part of the development of these facility documents dealing with the application of generic optimal DCS space information, several case study communication stations were designed to be constructed, implemented, and evaluated. These were done through the auspices of the MILDEPs responsible for DCS facilities. The reader is invited to carefully review the floor plan drawings and other section and elevation diagrams to understand the optimal capabilities and flexibilities of the design solutions. The reader is then referred to the generic design information for each space in Volumes 1A, 1B, and 2.

By using the examples presented in Volume 2, which have been derived from information on the various DCS facility types in Volumes 1A and 1B, the reader should be able to develop an optimal layout design for any communication station. Special conditions (survivability, security, etc.) that also must be considered when designing DCS facilities are referenced back to Volume 2. Therefore, the examples are intended to be studied to provide readers with an awareness of how the comprehensive generic facility information in Volumes 1A, 1B, and 2 can contribute to specific projects--they are not used as standard design solutions to be copied.

Of the examples, some are OCONUS new construction projects, some are OCONUS survivability retrofits at existing DCS sites, and the remaining ones are retrofits that improve operational conditions in transmission, switch, or control spaces of existing DCS buildings.

TRANSMISSION FACILITY MODULES

Digitization (182) B-12

One of the most important recent developments in all communications systems has been the continued transition to digital transmission. This trend is evident in military as well as in civil systems, and has been driven by several factors including:

1. The growing demand to transmit data that originates in digital form
2. Economic advantages of digital telephone terminal equipment
3. Improvements in transmission quality achievable with digital systems, particularly in the presence of interference
4. Increased use of digital switches
5. Development of new technology that has furthered the economic advantage of digital transmission.

Merger of communications and computers (182) B-23

The development of digital communications, coupled with the decreasing cost and increasing availability of computers, is resulting in a merger of communications and computers. The trend is reinforced by the increase in distributed processing which, because of the geographic dispersion of computers, has resulted in the need for computer communications networks.

At least two major issues accompany the evolving computer/communications movement: increasingly complex system control requirements and greater difficulty in determining which part of the network is the communicator's responsibility.

The increased complexity of system control requirements has resulted from the greater number and variety of system resources that must be monitored and coordinated as well as from added difficulties due to the geographic dispersion of resources. As an example, two changes resulting from this merger are the requirements for high-speed data transfer and data integrity protection. Neither of these was needed to support person/person communication or certain types of person/computer communication. Because of this change, bit-oriented data link control protocols with error control procedures have received increased attention in recent years.

The need for system control with expanded capabilities is being solved using automated network controllers, automatic patch panels, and equipment containing built-in test equipment (BITE), which may be remote-controlled. Conveniently, the computers that created the need for expanded system control have been used to implement the solution. Many aspects of system control have been automated and the resulting capabilities are resident in the host computer either as software or firmware. Diagnostic routines, for example, can be stored in microprocessor readout memory (ROM) and, upon command of a remote controlling computer, can be loaded into that microprocessor's random access memory (RAM) and executed. Several computer vendors offer these capabilities off-the-shelf as part of their computer network packages. Although operator intervention usually is required to initiate the network controls, additive software is required to monitor and control the distant resources and is usually included in the online central processor.

The control mechanism just described can be implemented in the application-dedicated computer or in the communications controlling computer, or distributed between them. Such functional dispersion has blurred the boundary between communications and the application. In the past, data terminal equipment (DTE) and circuit terminal equipment (CTE) defined the limits of the communicator's responsibility. Now that these are being controlled by computers and in some cases have been incorporated into the architecture of the computer itself, the end equipment may no longer serve as the point of demarcation. The communicator's hardware frequently is part of the same rack of equipment as the Automated Data Processing (ADP) hardware. The communicator's software for controlling equipment reconfiguration, equipment synchronization, and equipment diagnostics may be part of the same processor that processes the data.

This "movement of the boundary" back into the computer results in increasingly complex maintenance, particularly in fault isolation. Although fewer personnel are required to maintain the communications on a daily basis, those who do so find themselves interacting with a computer. Currently, the merger of communications and computers is far from complete; thus, both personnel with "traditional" technical control skills and those with software skills are required to maintain the communications. Because the boundary is moving toward a communications software/applications software boundary, coordination of the communicator with the user during requirements definition, development, and operation must be increased. Finally, a wide variety of designs accompanies the computer/communications merger--the communications software may be centralized (e.g., the classical dedicated front end processor (FEP), partially distributed (several FEPs coordinating the communications processing), or fully distributed (communications processing and applications processing both in network computers). (182) B-25.

Fiber optics

Fiber optics communications technology has developed rapidly since its development 15 years ago. Today it is a mature, proven technology being used in many commercial applications. The technology can be expected to improve in the next several years, but the major advances would be in standardization and cost reduction as manufacturing techniques are proven and refined.

Two major attributes of fiber optic systems are particularly attractive for military applications: the wide bandwidth for use in bus-type distribution systems, and the protection from electromagnetic (EM) radiation (EMI/EMC and EMP). The relationship between fiber optics and EMP has major potential in decreasing cost and improving survivability. (182) B-26

1. Reduction of fiber losses and costs

Several recent advances, all in the area of optical transmission media (i.e., the glass fibers), have combined to make fiber optics products feasible. Two major advances have resulted in a simultaneous dramatic reduction in fiber losses and costs: (1) the decrease in state-of-the-art fiber cable attenuation and the attenuation of a typical fiber cable compared with attenuations of several typical coaxial wire cables and (2) the constant optical fiber attenuation with increased modulation bandwidth, which is in contrast to the rapid wire cable losses. This can contribute considerable flexibility to system design and may allow the user to install a single type of cable in many systems, thus providing some standardization and simplifying logistics.

As a result of the dramatic cost reduction, it is estimated that fiber optic systems are approximately half as expensive as the coaxial wire system, and that the millimeter waveguide system does not become cost-competitive until a route capacity of 20,000 to 50,000 voice circuits is reached. Although fiber cable costs are projected to decline in the future, the increasing cost and decreasing availability of the metals used in wire cabling may cause the cost differential between these two systems to increase. This favorable economic picture, combined with the increasing efficiency of optical fibers, suggests that fiber optic

2. Splice connector technology

Work has also been continuing on the development of low-loss splice and connector technologies for optical systems. Current splice techniques use either fusion (melting together the optical fibers), to attain a 0.25-decibel loss, or epoxy bonding, to attain a 0.5-decibel loss. However, both of these techniques require reasonably clean, dry, dust-free environments to achieve these low losses and consequently are not well suited to field applications. Some experimental connectors have been developed that achieve a 0.5-decibel loss (a 1- to 2-decibel loss is characteristic of commercial connectors). These losses, from both connectors and splices, are generally enough for fixed-plant installations typical of commercial applications. Therefore, some development work can be expected, particularly in the area of connector standardization. No other large-scale efforts are foreseen.

3. Light sources

Most problems with optical systems in high-rate modulation and optical power availability have been eliminated. The introduction of light-emitting diodes (LED) and solid-state laser diodes have permitted very high data transmission rates, with experimental systems reporting modulation rates up to 4 gigahertz. Optical powers of 10 milliwatts or greater are now available from diode lasers. Most commercial light sources are in the 800- to 900-nanometer (nm) wavelength range, but considerable activity is being devoted to development of sources at 1200 nanometers for which fiber losses are much lower.

Millimeter waves

Millimeter wave technology continues to advance rapidly and is likely to see operational use in the 1990s. The characteristics of millimeter waves make it ideally suited for short-range communications, such as between a switching node and a remote user or cluster of users. These characteristics include: good penetration of bad weather, haze, fog, and smoke; a narrow wave path that reduces ground and multipath clutter and minimizes the probability of detection, eavesdropping, and jamming; and the ability to construct efficiency antennas of small size. (182) B-30

Satellite Communication [SC]

SC1 Security SC-2
SC2 Administration SC-8
SC3 Personnel Support/Break Area SC-12
SC4 Training SC-16
SC5 Operations SC-22
SC6 Maintenance SC-28
SC7 Parts SC-32
SC8 Transmission SC-36
SC9 Cryptography (Red/Black) SC-44
SC10 UPS (Uninterrupted Power Source) SC-50
SC11 Battery SC-56
SC12 Generator SC-62
SC13 Mechanical SC-68
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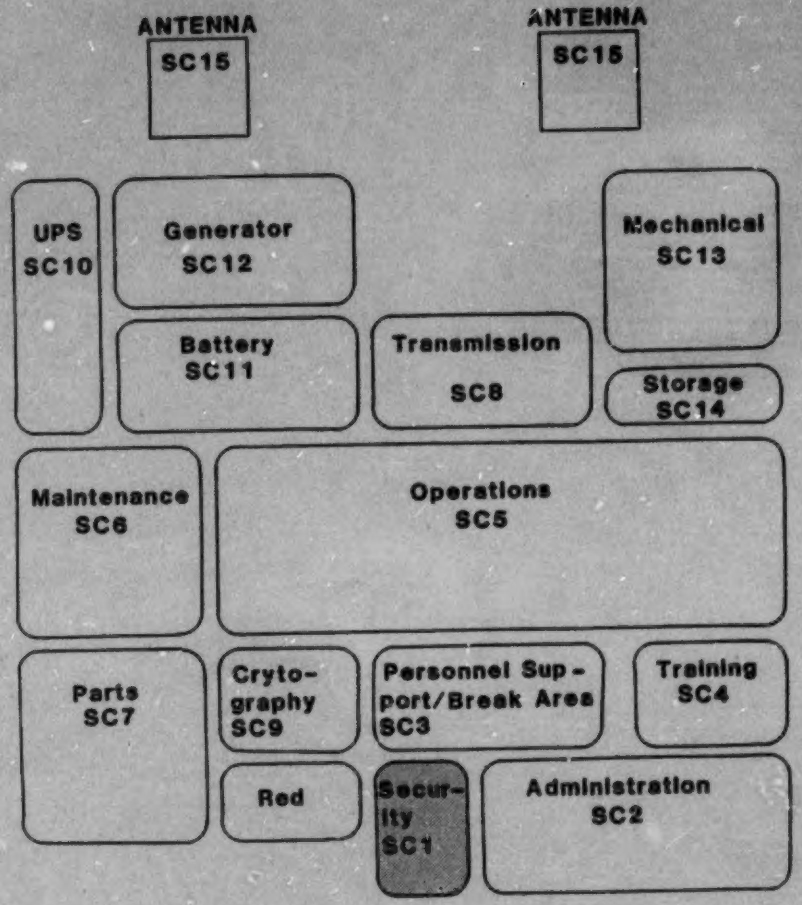
SC15 Antenna Disk SC-76
SC16 Standardized Modules SC-92

The satellite communication system has several advantages that make it attractive as either a replacement for, or a backup to, present terrestrial systems. These advantages include increased channel capacity, relative terrain independence, and (under some conditions) higher resistance to jamming efforts. Satellite communications will continue to expand as a burgeoning technology provides advances in modulation techniques and frequency utilization. With these advances, satellite networks will lend themselves readily to the Defense Communications Agency (DCA) plan for increased use of digital communications. The systems engineering objectives for earth stations in the Defense Satellite Communications System (DSCS) will emphasize sustaining and improving survivability, durability, security, and interoperability. Terminal interconnectivity structure is expected to shift from the present configurations of terrestrial backbone transmission and switching networks to direct access by satellite. (1) 1

Modern long-haul telecommunications circuits are now carried by communication satellites that relegate the more expensive (per circuit mile) and less reliable high-frequency (HF) modes to a backup role. However, space technology together with electronic warfare has advanced to render satellite communications, and thus, military long-haul communications, highly vulnerable in the event of an international conflict involving the United States. (87) Vol 1, 10

SECURITY SC1


ANTENNA
SC15
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Generator
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Battery
SC11
Transmission
SC8
Storage
SC14
Maintenance
SC6
Operations
SC5
Parts
SC7
Cryto-graphy
SC9
Personnel Sup-port/Break Area
SC3
Training
SC4
Red
Secur-ity
SC1
Administration
SC2

function

This component provides overview for verifying visitors before they enter the facility. The Intrusion Detection System and fire alarm equipment are monitored in this area. Also, when required, facility personnel weapons are stored and distributed here.

policy/sop

1. The building site must withstand intrusion by individuals or groups intending to compromise the security of the information transmitted and received at DCS facilities.

2. The overall approach to providing security at DCS sites consists of five elements: (1) intrusion deterrence, (2) intrusion detection, (3) alarm assessment, (4) component and physical plant hardening, and (5) security or response force personnel. Intrusion deterrence is intended to produce a psychological state of mind in a potential intruder that intrusion will result in unacceptable counteraction. Intrusion detection is intended to provide an alarm to the operating activity or security personnel that an unauthorized intrusion has occurred at a DCS site. Alarm assessment is intended to verify that an intrusion alarm was activated by a threat against the DCS site. Component hardening of the physical security system is intended to delay the damages or to limit the amount of damage that can be inflicted on a site. Security force is intended to delay, stop, or mitigate the actions of an intruder. Every DCS site security program shall be prepared to include these five elements. (9) 4.3.3.1

3. The security alarm system should also be wired into either Tech control or the operation area spaces. These spaces will be staffed 24 hours per day, and the same personnel could monitor the security system. The receiving/administrative spaces usually are staffed only 8 hours per day during the week.

4. Most OCONUS sites have local national (LN) guards that maintain security at the perimeter fence during daytime hours. At night this function reverts to site shift communication personnel. All entry alarms should be "remoted" to locations within the operations building similar to that of closed-circuit television (CCTV) monitors. This will preclude assigning critical personnel to security duties. All alarm systems should be "remotable" to the operations console.

issues and assumptions

1. Full-time lighting versus "on-demand" lighting

Continuous lighting (stationary luminaires) is the most common security lighting system. It consists of a series of fixed luminaires arranged to flood a given area continuously with overlapping light cones during the hours of darkness. Standby lighting differs from continuous lighting in that standby lighting is intended to create an impression of activity. The luminaires are not lighted continuously, but are either automatically or manually turned on at random or when suspicious activity is detected or suspected by the security force or the intrusion detection system (IDS). This technique may offer great deterrent value as well as economy in power consumption. (37) 13.1-120

2. Automatic actuation of security lighting versus manual lighting

A deterrent lighting system can be developed to turn lights on at random or, rather than randomly activating the luminaires, an IDS sensor can be used to turn on the lights when an intruder is detected. This type of active lighting system provides maximum deterrent value at a low duty cycle. (37) 13.1-124 Automatic actuation of lights for normal operations seems most advantageous; however, manual override should be provided for control.

activities

1. Viewing personnel entering the complex.
2. Monitoring IDS equipment.
3. Operating facility physical security program.
4. Distributing and storing personnel weapons.

personnel

1. One.

equipment *

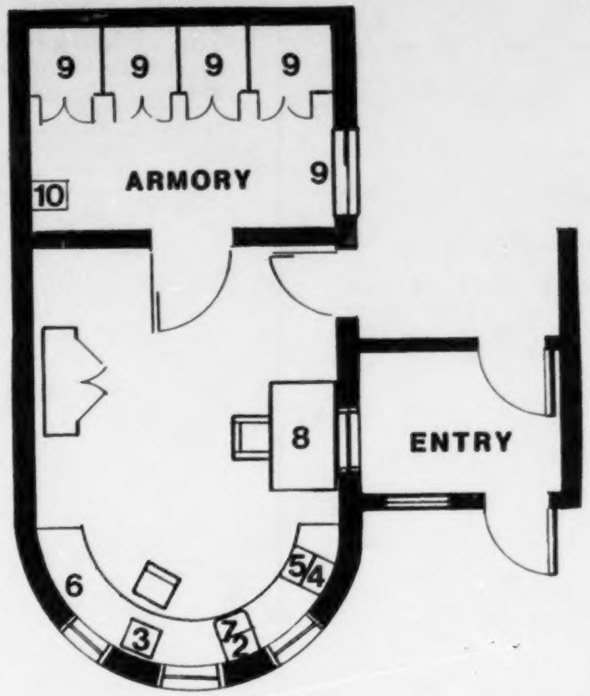
1. Pass window for identification.
2. Annunciator panel (sensor information).
3. Closed-circuit TV.
4. Gate control for perimeter security fencing.
5. Exterior lighting control.
6. Communication link to host agency.
7. Alarm for intrusion detection to host agency security office.
8. Desk (or counter unit) with chair.
9. Racks for personnel weapons. Weapon distribution is through a door with a daygate for passing through.
10. Humidifier.
11. Intercom speaker.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate IDS equipment and personnel associated with security component.	**1.** Provide space for one person who verifies and monitors the facility's security. This area varies with size of facility, but typically is 400 to 500 square feet.	
2. Visual verification of entering personnel.	**2.** Provide a pass window.	
3. Communication and electronic monitoring lines.	**3.** Coordinate IDS components into a centralized module. Provide an annunciator panel with telephone and intercom link-ups. The operation room console should have remote alarms along with a CCTV monitor.	**3.** See SB7 Vol. 2 for additional guidance on securing doors and entrances
4. Resistance against penetration from the outside and for the armory.	**4.** Windows should be glazed and hardened to prevent penetration (bullet-proof glass). Windows also should be designed for full visibility over approaches to the point of entry.	**4.** See Vol 2, SB7, Security (Zone 3), for more information.
5. Interior finishes suitable for durability, maintenance, and room function.	**5.** Floor--Vinyl asbestos tile. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	**5.** See also Vol 2, SB2, Interior Construction and Finishes.
6. Acoustical isolation and attenuation for a nondisruptive environment.	**6.** The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum), floor surface at NRC .25 (minimum), and divider partitions (if used) at .85.	
7. Adequate lighting to review entering personnel and monitoring equipment.	**7.** Lighting shall be specially engineered. Low levels of lighting may be required to permit observation of luminous panels without reflected glare or undesirable contrasts in brightness. Separately controlled luminaires shall be provided for normally lighted operations and clean-up; this lighting should have an ambient level of 70 footcandles using fluorescent fixtures.	**7.** For further information on quality of lighting design using the ESI concept, see Vol 2, SB2, Electrical Lighting.
8. Thermal regulation and other comfort features for the occupant.	**8.** Maintain temperature at 68°F (heating) or 78°F (cooling) with a 5 cubic feet per minute per person outside air ventilation rate. A dehumidifier may be required in the armory. Provide a chair with seat height adjustment, casters, swivel, and independent back rest adjustment.	**8.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
9. Electrical power.	**9.** Provide 120/208 electrical service. 120-volt receptacles should be located for convenience at all workstations and workbenches at the appropriate height and for every 10 linear feet of wall. Frequency levels should be 50 to 60 hertz ± 5 percent.	**9.** See also Vol 2, SB2, Communication Station Buildings--Electrical.

requirements	criteria	commentary
10. Fire protection/life safety criteria are based on the assumption that this facility houses critical equipment and data that has a severe strategic fire loss potential.	**10.** Interior enclosure walls--2-hour fire-rated construction in armory, security, and entry. Interior doors--1.5-hour fire-rated doors in armory, security, and entry. Interior finish--Class A or B only. Corridor and entry finish--Class A only. Automatic fire detection--Local alarm. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**10.** See Standardized Modules-Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety for more information.

guidance



11 -- speaker in ceiling

guidance

1. Location

The minimum area is determined from IDS monitoring equipment physical dimensions.

Direct access to facility entrance is required.

This area must have no direct access to C-E equipment.

This component can be combined with the administration function in the small module package.

2. Verification

Orient windows to allow visual security of arriving personnel. In some circumstances, it works well to use mirrors to show the total front face of the building before the door is opened. This also prevents the security officer from confronting unexpected hostile action when leaving.

3. Monitoring

Three shifts in a 24-hour period are assigned for these activities if the personnel are available. At some smaller facilities, the security alarm and detection devices should also be wired into the operations, operations administration, or control monitoring space so that operation shift personnel can monitor the security system when the security space is not staffed.

Alarm system--Provide a wall-mounted alarm terminal panel in the security room. The following alarms will terminate there:

- Smoke/fire detection
- Intrusion detection of all doors and barred openings.

The termination board or its associated housing should have all alarm terminations identified clearly with permanent marking or labels. This allows future extensions of these connections to a control and fault alarm system. The alarm sensors should incorporate only dry contacts (no voltages) and should use two conductor shielded cables in the circuit runs (or in conduit) to the consolidated terminal panel noted above.

Intrusion detection system--The IDS should conform to Corps of Engineers Guide Specification CE 304.01. Provide magnetic intrusion alarm switches on all exterior doors and openings greater than 7.6 feet at the perimeter into the building. Terminate all circuits in the wall-mounted alarm panel. The door alarm is to sound then the door moves 1/2 inch toward an open direction.

guidance

The various approaches to an alarm display problem offer a wide range of capabilities, but also present several distinct disadvantages. In selecting an alarm display system for a specific installation, it is essential that the features and capabilities required for the intended application be well understood. In particular, there is no one "best" system for transmission and display of security information. Rather, a system should be selected to meet the needs of the specific installation. It should also be noted that many systems may provide more capability than is needed or desired and that paying for unused features would tend to increase the system's cost. See Vol 2, SB7, Security Systems, for more information.

4. Primary entrance door

The primary personnel entrance door should be secured with a jimmy-proof, deadbolt extension operated by a combination lock in conformance with UL Standard 768 and Military Specification MIL-L-15596. The primary entrance door should also be equipped with panic bolts and a rim with a box mullion in conformance with Federal Specification FF-H-106. The panic bolts should be UL-approved. If required for routine access control, an electrically controlled latch mechanism is authorized for installation. RF emissions should meet the requirements of MIL-STD-461 of Class II-A equipment when applicable. (5) 3-5-9

The personnel entry doors should be the steel, single-swing type with a steel frame. Another option is a door constructed of hollow metal with a 1/8-inch steel plate face.

Personnel entry doors should also be equipped with a "peephole" wide angle lens. Doors should have an inside plate to cover the peephole when it is not in use.

Hinges on both the exterior personnel and equipment doors must be welded to prevent removal of hinge pins if pivots and pins are on the outside.

7. Lighting design

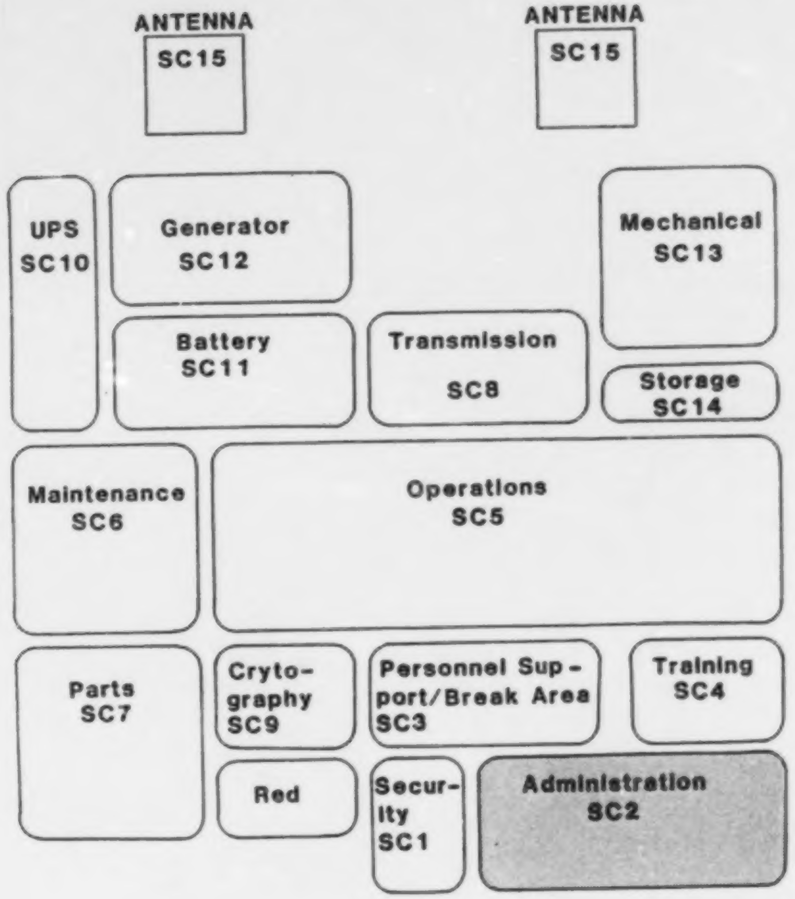
To reduce glare at video digital terminals (VDTs), use fluorescent light fixtures with specular parabolic louvers. A louver with cell dimensions of 1.5 by 1.5 inches or smaller will give a high visual comfort probability (VCP) value. A diffuser along with a parabolic louver may also be helpful. Some pigmented acrylic lenses and nonparabolic metal louver panels can also have high VCP values.

The suggested cell size for a parabolic louver is 1 by 1 inch down to .5 by .5 inch. On tall ceilings, the cell depth must be greater; this may dictate a larger cell size.

Glare from windows and reflections from walls and other surfaces must be controlled, especially on the surface immediately behind the VDT. Walls and work surfaces with a matte finish are best. Wall carpeting is also recommended for its noise control and virtual elimination of reflections.

guidance

ADMINISTRATION SC2


ANTENNA
SC15
ANTENNA
SC15
UPS
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Generator
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Mechanical
SC13
Battery
SC11
Transmission
SC8
Storage
SC14
Maintenance
SC6
Operations
SC5
Parts
SC7
Cryto-
graphy
SC9
Personnel Sup-
port/Break Area
SC3
Training
SC4
Red
Secur-
ity
SC1
Administration
SC2

function

This component establishes and maintains the station administrative processing of personnel records. In addition, this section implements written and verbal SOP directives from "Chain of Command" orders, host agency regulations, and DCA policy for DCS. The administration area provides a buffer and transition space between exterior and secure interior spaces.

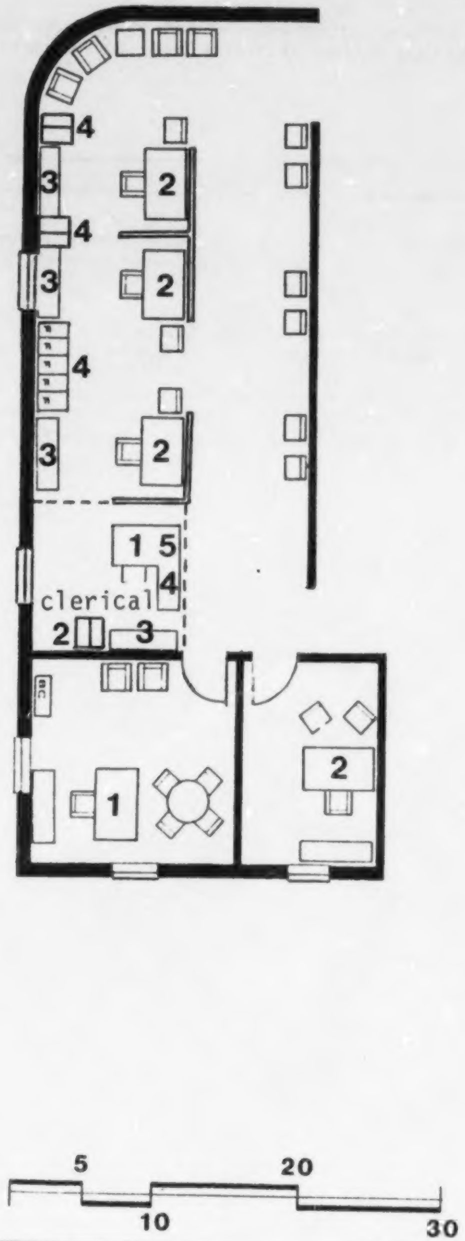
policy/sop

issues and assumptions

activities	personnel	equipment *
Officer-in-charge (OIC) 1. Distributing directives, orders, and policy statements, both written and verbal, to shift supervisors. 2. Initiating evaluation of equipment capabilities. 3. Developing personnel training plans and equipment evaluations.	1. Site chief or OIC. 2. NCOIC and chief-in-charge. 3. Two NCO's	1. Site chief workstation: • Desk/chair (enclosed) • Two side chairs • Credenza. 2. NCO workstations: Desk/chair in open area (or with dividers). 3. Bookshelves--20 linear feet. 4. Nine files with five drawers each.
Clerical 1. Typing, reception, and coordination of command/control process for the noncommissioned officer in charge (NCOIC). 2. Filing/posting of operations and personnel documents. 3. Providing courier service for paperwork.	1. One E-2 clerk (two at some installations).	1. Clerk workstation: Desk/chair (open area). 2. Two files with five drawers each. 3. Bookshelves--45 linear feet. 4. Typewriter(s)/word processor(s). 5. Operational voice intercom control. * see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate equipment and furniture associated with the administrative function.	**1.** Provide administrative space for supervisory personnel. This area varies with the number of assigned personnel, but is typically 700 to 800 square feet.	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Carpet. Base--Glazed structural units, rubber, vinyl or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation and attenuation for a nondisruptive environment.	**3.** The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum), floor surface at NRC .25 (minimum), and divider partitions (if used) at .85.	**3.** See reference 201, page 3-4, Table 3-2.
4. Adequate lighting.	**4.** Provide 80 footcandles for task lighting at work surfaces with 40 footcandles for the ambient level. Surface reflectances should be: • Ceilings--80 to 90 percent • Walls--40 to 60 percent • Floor--20 to 40 percent.	**4.** For further information on quality of lighting design using the ESI concept, see Vol 2, SB2, Electrical--Lighting.
5. Thermal regulation and other comfort features for the occupant.	**5.** Maintain temperature at 68°F (heating), 78°F (cooling), with 5 cubic feet per minute per person outside air ventilation rate. Provide a chair with seat height adjustment, casters, swivel, and independent back rest adjustment.	
6. Electrical power.	**6.** Provide 120/208 electrical service. 120-volt receptacles should be located for convenience at all workstations and workbenches at the appropriate height and every 10 linear feet of wall. Frequency levels should be 50 to 60 hertz ± 5 percent.	**6.** See also Vol 2, SB2, Communication Station Buildings--Electrical
7. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	**7.** Interior finish--Class A or B only. Corridor finish--Class A only. Automatic fire suppresion--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunicator panel and local fire department or constantly staffed station outside the facility.	**7.** See Standardized Modules--Building Design Principles and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



guidance

1. Location

Windows to the outside are recommended for CONUS facilities on secure sites, such as military installations. OCONUS facilities usually should have a minimum of windows to limit opportunities for forced entry.

Activity subspaces

- Enclosed offices
- Workstations
- Filing area
- Reception.

3. Acoustical and visual privacy

Divider partitions between workstations ,should be 60 inches high (± 4 inches) to provide visual privacy while occupants are seated--and yet should not be confining. Circulation paths around workstations should minimize disturbances to other workstations.

4. Lighting designs

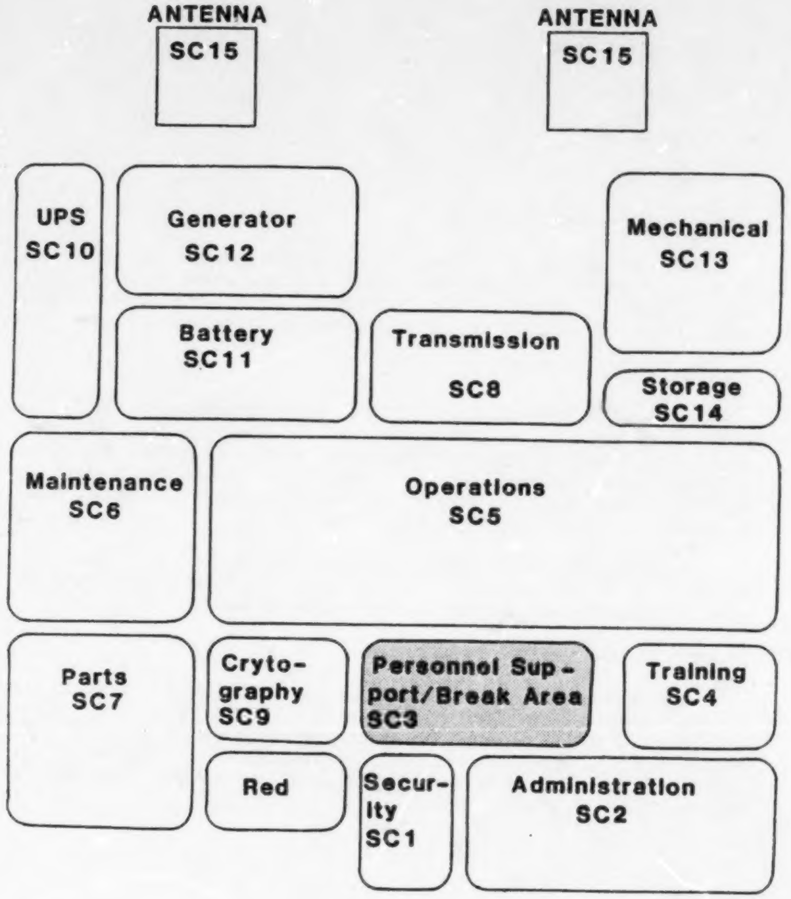
To reduce glare at workstations, equip fluorescent light fixtures with specular parabolic louvers. A louver with cell dimensions of 1.5 by 1.5 inches or smaller will give a high VCP value. A diffuser used along with a parabolic louver may also be helpful. Some pigmented acrylic lenses and nonparabolic metal louver panels can also have high VCP values.

The suggested cell size for a parabolic louver is 1 by 1 inch down to .5 by .5 inch. For tall ceilings, the cell depth must be greater and this may dictate a larger cell size.

6. Electrical power

Workstation divider partitions can be tackboard surfaces to display maps, job examples, service equipment, and other information. Floor-to-ceiling poles are recommended to distribute electrical and communication lines to workstation modules. This eliminates floor wires at circulation paths and allows future module modifications at minimal cost.

PERSONNEL SUPPORT/BREAK AREA SC3


ANTENNA
SC15
ANTENNA
SC15
UPS
SC10
Generator
SC12
Mechanical
SC13
Battery
SC11
Transmission
SC8
Storage
SC14
Maintenance
SC6
Operations
SC5
Parts
SC7
Cryto-graphy
SC9
Personnel Sup-port/Break Area
SC3
Training
SC4
Red
Secur-ity
SC1
Administration
SC2

function

This component creates a change of environment for on-duty personnel to provide a break from the hard-surface equipment room and work areas.

policy/sop

1. The intense activities in the DCS facility generate personnel fatigue, making it necessary to separate personnel from the communication function.

2. Current policy requires personnel to have a 15-minute break every 3 to 4 hours. Typical schedules also allow 30-minute meal breaks.

3. Most communication personnel "brown bag" their meals since they cannot leave the facility during a shift. Therefore, basic food preparation capability is required: sink, hot plate, refrigerator, cabinets, and range.

issues and assumptions

activities

1. Relaxing.
2. Reading.
3. Eating.
4. Storing food.
5. Preparing food.
6. Storing personal items such as coats and books.

personnel

1. Two to eight at once.

equipment *

1. Refrigerator.

2. Stove.

3. Range and range hood.

4. 20 x 30 inch sink in countertop which is a 6-foot minimum with cabinets above.

5. Coffee machine.

6. Chairs.

7. Table with chairs for eight.

8. Bulletin boards.

9. Intercom speaker.

10. Storage lockers for each person. (Not required for personnel who have private offices.)

11. Coat rack.

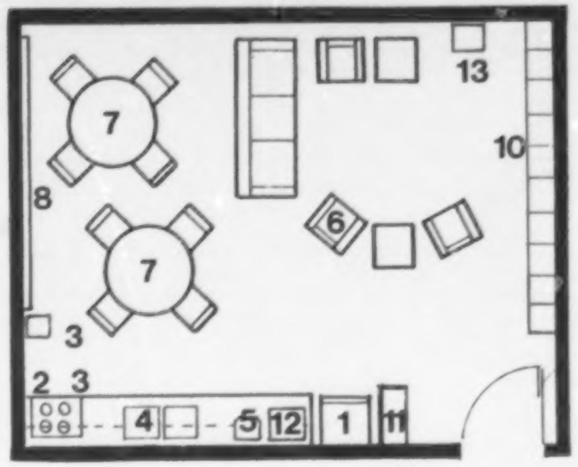
12. Microwave oven (if communication equipment is not affected).

13. Trash receptacles.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate equipment and furniture associated with the personnel support/break area.	**1.** Provide approximately 500 square feet of space for equipment and furniture to accommodate up to 15 personnel.	
2. Visual separation from the communications equipment.	**2.** Provide visual separation that also allows viewing of the operations area when desired. Supply comfortable furniture and carpeting (earth tones are recommended).	
3. Interior finishes suitable for durability, maintenance, and room function.	**3.** Floor--Vinyl asbestos tile and area carpeting. Base--Glazed structural units, rubber, vinyl or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	**3.** See also Vol 2, SB2, Interior Construction and Finishes.
4. Acoustical isolation and attenuation for a nondisruptive environment.	**4.** The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum), floor surface at NRC .25 (minimum), and divider partitions (if used) at .85.	
5. Lighting suitable for reading (task and ambient).	**5.** Use 20 to 30 footcandles for ambient lighting and 100 footcandles for task lighting.	
6. Thermal comfort.	**6.** Control temperature for 68°F (heating) and 78°F (cooling) with a 5-cubic feet per minute per person outside air ventilation rate.	**6.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
7. Electrical power.	**7.** Provide 120/208 electrical service. 120-volt outlets should be installed for every 10 linear feet of wall. Counter height outlets are required for a coffee maker, mixer, microwave oven (when permitted), and other appliances.	**7.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
8. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	**8.** Interior finish--Class A or B only. Corridor finish--Class A only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**8.** See Standardized Modules--Building Design Principles and Vol 2, SB3, Fire Protection/Life Safety for more information.

guidance



9 -- speaker in ceiling

guidance

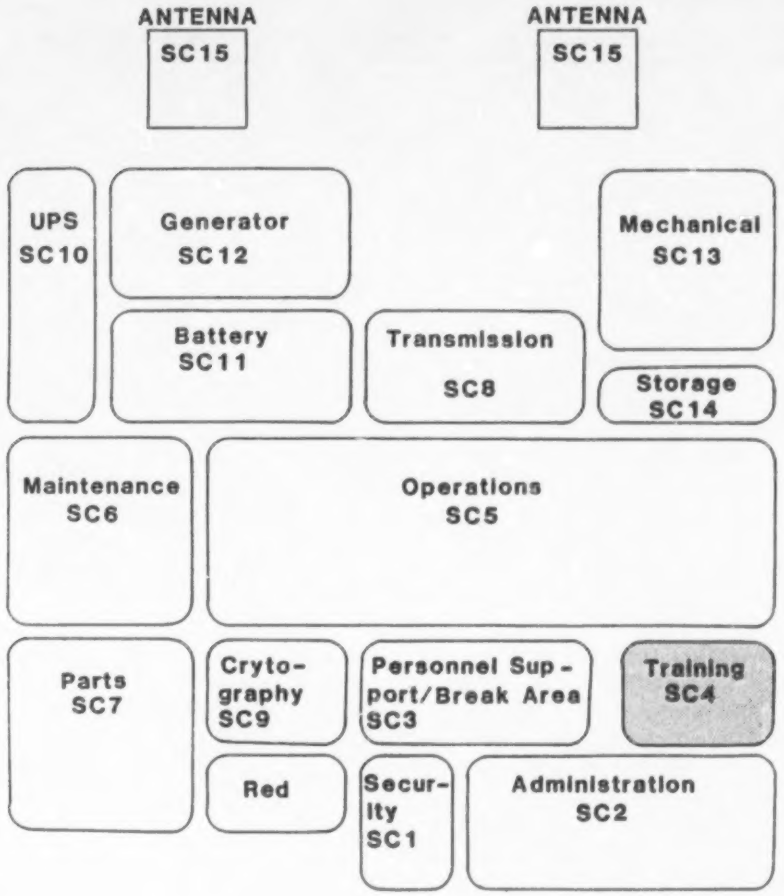
1. Location

The personnel space should be directly adjacent to the operations room, but isolated acoustically (absorptive walls) and visually (a curtain hung at the window).

3. Visual comfort

The color contrast, textures, and designs of the wall, ceiling, and floor surfaces should minimize glare for a comfortable environment.

TRAINING SC4


ANTENNA
SC15
ANTENNA
SC15
UPS
SC10
Generator
SC12
Mechanical
SC13
Battery
SC11
Transmission
SC8
Storage
SC14
Maintenance
SC6
Operations
SC5
Parts
SC7
Cryto-
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SC9
Personnel Sup-
port/Break Area
SC3
Training
SC4
Red
Secur-
ity
SC1
Administration
SC2

function

This component is for enhancing personnel abilities and effectiveness, both technically and personally. Development and implementation of the station master training program is done here.

policy/sop

1. Technical training occurs at two levels: (1) hands-on training, i.e., working directly with the communications equipment, and (2) learning from manuals, publications, and audiovisual equipment. The physical training also occurs at two levels: (1) interior individual exercise and (2) exterior small-group recreational activities, especially at remote DCS facilities that are not on a military installation.

2. Current policy requires personnel to be allowed time to train technically while on-duty at the facility.

3. Training usually is done during the times that the communication activity is at its lowest level.

4. Some communications personnel are engaged in a Career Development Course (CDC); thus, a training area is required. The Air Force counterpart is the Quick Training Package (QTP).

5. Training usually is conducted by the shift supervisor or a lead NCO/CO who is also on-duty.

6. In fire/life/safety training, safety implies the absence and/or control of conditions that can cause personal injury, death, damage to, or loss of equipment or property. Within the system, safety is concerned with the elimination or control of factors affecting the safe and efficient operation of personnel, equipment, and facilities organized to attain a common goal. The objective of safety training therefore is to insure maximum freedom from inadvertent and possibly destructive mishaps resulting from facility equipment, procedural, or personnel deficiencies during all phases of system operation. (70) 15-30

issues and assumptions

1. Three-shift versus four-shift impact on training time available

Most facilities operate on a three-shift basis:

- Day shift 8 a.m. to 4 p.m.
- Swing shift 4 p.m. to 12 a.m.
- Midshift 12 a.m. to 8 a.m.

By having personnel assigned to four shifts instead of three, one group could be a "training shift" that would be on duty during the day shift; thus, the peak activity period would have double the personnel available if required, plus give trainees the best opportunity to interact with facility functions.

The four-shift concept, however, assumes one or both of the following:

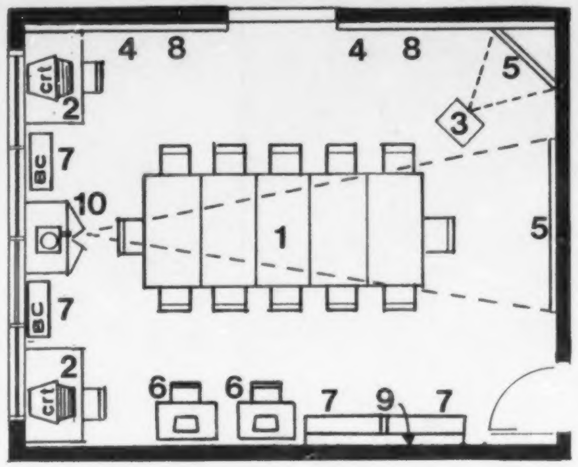
- More persons will be assigned to the site
- Staffing for the three operating shifts can be reduced.

activities	personnel	equipment *
Technical training 1. Observing and evaluating personnel records; conducting personnel interviews to determine training requirements. 2. Developing overall master training plan and presenting special MOS training module program for a specific focus. 3. Studying manuals and other publications. 4. Watching video cassettes, 16-millimeter movies, and slides. 5. Instructing in fire/life/mission safety.	Instructors 1. Commander. 2. NCOIC. 3. Civilian technicians (not an office area for personnel). * see "guidance" box for example layout of all equipment listed.	Classroom/conference room **1.** Table and seating for 12. **2.** TV monitor/CRT terminal. **3.** Viewgraph projection. **4.** Charts and display panels. **5.** Audiovisual projection and screens. **6.** TEC library monitors. **7.** Library of written instructional materials--20 linear feet. **8.** Chalkboard. **9.** Tackboard for training and information bulletins. **10.** Audiovisual equipment storage cabinet. **11.** Intercom speaker.
Physical training 1. Involves mandatory military training requirements for physical fitness, weapons qualifications, and CBR training.		Fitness area **1.** Exercise equipment: 8 by 4 foot mat, weight set, and exercycle. **2.** Exterior area for volleyball and half-court basketball. **3.** Athletic and recreational items; balls, bats, horseshoes, etc. **4.** Intercom speaker.

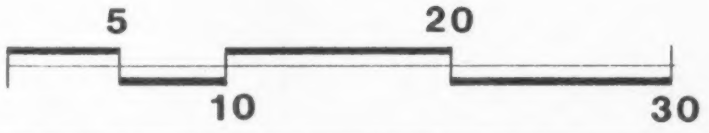
requirements	criteria	commentary
Technical training		
1. Enough space for small groups (up to 20 people) that meet for small training seminars. Space for reading and studying manuals and other publications associated with the training function.	**1.** Provide 25 square feet of space per person. Equipment layout and storage require additional square footage.	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Vinyl asbestos tile. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation from the high noise level generated in the operations area.	**3.** The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum), floor surface at NRC .25 (minimum), and divider partitions (if used) at .85.	**3.** See reference 201, page 3-4, Table 3-2.
4. Flexible lighting.	**4.** Provide adjustable lighting, depending on varied uses. • 20 to 80 footcandles at each work surface. • 10 footcandles at rear of room during audiovisual projection. Surface reflectances should be: • Ceiling: 80 to 90 percent • Walls: 40 to 60 percent • Floor: 20 to 40 percent.	**4.** For further information on quality of lighting design using the ESI concept, see Vol 2, SB2, Electrical--Lighting.
5. Thermal regulation and other comfort features for occupants.	**5.** Regulate temperature at 68°F (heating), 78°F (cooling) with 5 cubic feet per minute per person outside air ventilation rate. Seating should be adjustable to provide maximal body support comfort for many different sizes.	**5.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
6. Electrical power.	**6.** Provide 120/208 electrical service. Provide 120-volt outlets--one receptacle for every 10 linear feet of wall. Specific equipment outlets depend on the room layout.	**6.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
7. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	**7.** Interior finish--Class A or B only. Corridor finish--Class A only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**7.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

requirements	**criteria**	**commentary**
Physical training		
1. Enough space to allow each person to perform physical exercises and workouts.	**1.** Minimal area of approximately 150 square feet (10 by 15 feet).	

guidance



11 -- speaker in ceiling



guidance

1. Location

Since most technical training involves hands-on experience with the communications equipment, the training room should be adjacent to the operations space and should have a view into the operations space if possible.

4. Lighting design

Classroom lighting immediately in front of a lecture platform can be controlled from a point convenient to the speaker's platform and also at the entrance. Lighting can be controlled by motor-operated dimmers from the platform and the main entrance to facilitate use of audiovisual aids. Lighting can also be controlled from those points by switches. Minimum lighting shall be provided so that notes can be taken during the use of visual aids.

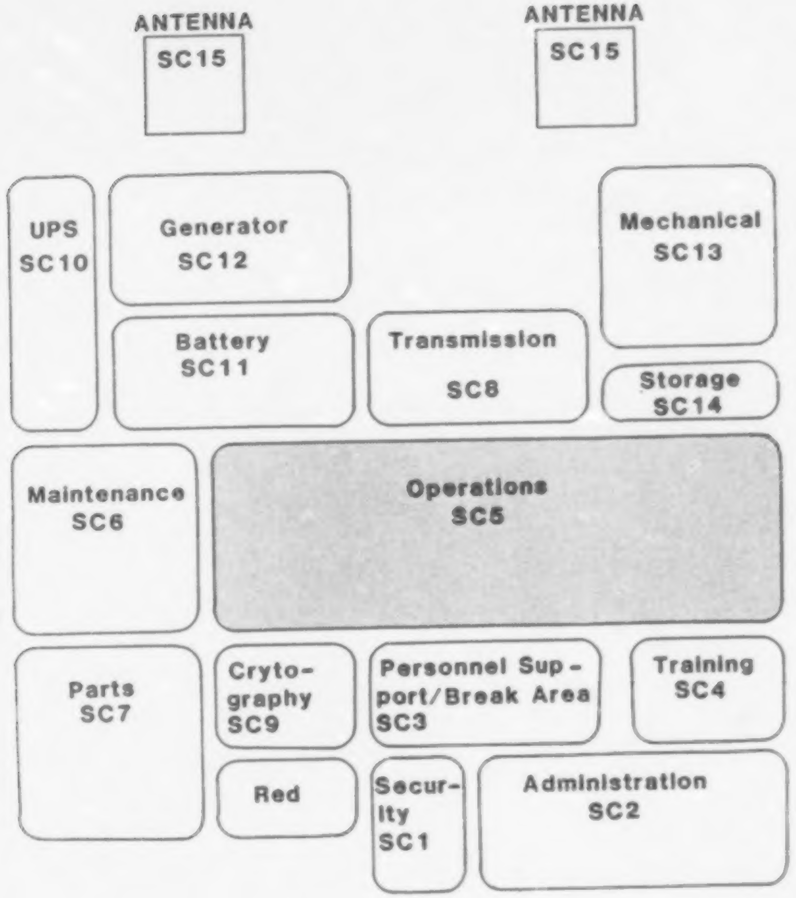
1. Physical training

See "storage" for interior physical training area guidance drawing.

guidance

guidance

OPERATIONS SC5



function

The operations room allowed personnel to operate, maintain, monitor, and repair communications equipment optimally.

policy/sop

1. Equipment and equipment layout should be standardized as much as possible among the facilities comprising a communications system. In determining the layout for facilities in which unencrypted signals bearing classified information are present or processed, the specialized installation guidance found in MIL-HDBK-232(C) must be consulted. Another major consideration is the access necessary for installation, maintenance, and operation. This would include considerations such as providing adequate space between rows of equipment to allow for opening cabinet doors or sliding out modules for maintenance. Another major, but less important, consideration is providing the shortest and most direct waveguide run practical. (2) 5-20

2. Other equipment layout considerations include minimizing interbay cabling runs, providing for future expansion, and providing easy access for maintenance and operational convenience. Sometimes the EM incompatibility of various types of equipment or inadequate ventilation for personnel and equipment can cause problems. Equipment of the same type or with similar function is usually grouped together except when impractical due to size and specific requirements of a station. (2) 5-20

3. Equipment should be grouped properly according to its function and interoperation. Care and thought should be given to the arrangement of meters, test equipment, jackfields, indicating lights, and other such items to insure they are placed approximately at eye level, thus allowing more rapid and convenient use. Equipment should not be mounted at the bottom of a bay if it can be damaged easily or if its size and shape will interfere with power boxes or other hardware at the bottom of the cabinet or rack. Most microwave radio equipment comes fully packaged with all components already mounted in a cabinet or rack. (2) 5-21

4. The station's operational plan must be studied to determine communication circuit requirements when placing each component or rack assembly. In small stations, it is recommended that the equipment be aligned in a row along, one or, if need be, both sides of the building with enough space in between to accommodate a normal floor traffic pattern. However, this type of layout generally will not be suitable in stations for which large quantities of equipment are involved. In the large station, the most practical layout is usually one in which the equipment is aligned in bays across the width of the room, with enough space between bays to permit free access to each rack assembly. (2) 5-22

issues and assumptions

1. Automated record keeping

CRTs with hardline printers can streamline paperwork by storing all circuit history files on disk. This will allow more rapid troubleshooting in-house.

2. Electromagnetic compatibility (2) 5-43

Electromagentic compatibility (EMC) is a complex subject, so that specialists often must perform the type of EMC study needed to insure the equipment or equipment layout produces no interferences or radiation hazard.

DOD is working on new regulations to control permissible levels of EM pollution of the frequency spectrum. This work reflects the concern for environmental protection. Radiation hazards also are being regulated through concern for occupational safety. Engineering agencies working for the Government must therefore know the legal and regulatory aspects of EMC and radiation hazards to meet these requirements.

Military specifications on EMC such as MIL-STD-461, -462, and -463 are intended to control and achieve an acceptable figure of merit or quality in the development of new communications equipment. They do not eliminate the need for EMC engineering in facility design. In addition to equipment quality, the frequency selection, nearness to other facilities and, to some extent, the facility design itself are variables in the interference generation problem. (2) 5-43

3. Determining the correct shielding procedure

A comprehensive approach to the shielding of equipment from radiofrequency interference (RFI) or TEMPEST involves (a) a building layout to optimize inherent facility shielding conditions, (b) suitable location of all electronic equipment and signal cables, and (c) selection of effective shielding materials and construction components.

See Vol 2, SB4, for additional guidance information.

activities

1. Monitoring communication equipment (patch and test).
2. Isolating fault.
3. Doing quality control maintenance tests.
4. Troubleshooting and patching to good equipment.
5. Identifying bad connections.
6. Writing and typing reports.
7. Conducting training sessions.

personnel

1. OPS NCOIC.
2. Two to six operators.

equipment*

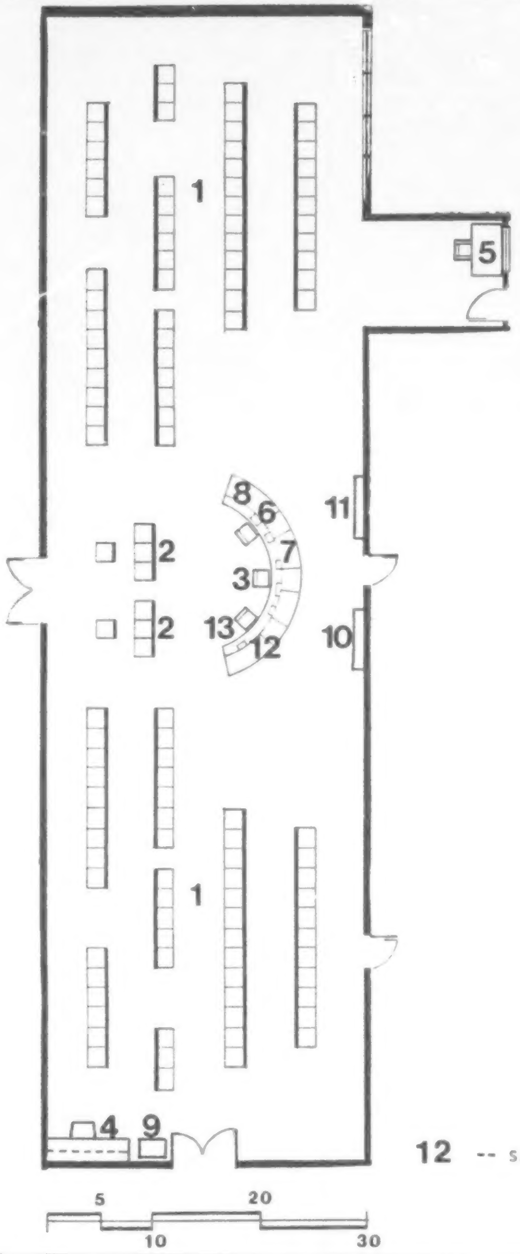
1. Electronic communication system.
2. Patch bays.
3. Control console.
4. Workbench (6 linear feet) with shelving for manuals.
5. Desk with chair.
6. CRT at console.
7. Telephones.
8. Typewriter(s) or word processor(s).
9. Filesafe.
10. Electrical shock first-aid-kit.
11. Alarm panel.
12. Operational voice intercom control.
13. Record file (10 drawers).

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Adequate space for the operation and monitoring of communications-electronics (C-E) equipment. Spatial requirements must allow for proper spacing between equipment to facilitate easy maintenance.	**1.** Varies due to extent of communication equipment designed. See layout in Guidance.	
2. A secure environment for C-E equipment.	**2.** The operations room must be lockable when unstaffed and must be supplied with an intrusion alarm system. The operations console should be fitted with alarms for intrusion, power failure, and generator status. Covers should be provided on overhead rods for rapid sanitizing of applicable equipment.	**2.** See Vol 2, SB7, Security (Zone 3), for more information.
3. Signal shielding.	**3.** See Vol 2, SB4--Grounding, Bonding and Shielding along with SB7--Security Systems for more information.	
4. EMP/HEMP shielding.	**4.** Shielding is necessary for survivability and uninterrupted functioning when the facility is subjected to EM pulse (EMP) and high-altitude EM pulse (HEMP). Protective measures are based on intercepting the incident energy and dissipating it or reflecting it away from the threatened device, equipment, or facility.	**4.** See Vol 2, SB5, EMP/HEMP Protection, for more information.
5. Raised floor system.	**5.** Raised or false floors are necessary for proper cooling of the equipment.	**5.** See also Vol 2, SB2, Communication Station Buildings--Architectural.
6. Interior finishes suitable for durability, maintenance, and room function.	**6.** Floor--Vinyl asbestos tile panels. A raised floor system shall be used over a concrete floor with a dust-on finish that contains a hardener. See Vol 2, SB2--Interior Construction. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Wall--Paint over concrete, gypsum board, or plaster and acoustic tiles to within 4 feet of the floor. Ceiling--Acoustic tile.	**6.** See also Vol 2, SB2, Interior Construction and Finishes.
7. Acoustical isolation attenuation for variable noise levels produced by electronic equipment.	**7.** Adjacent room walls should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum) and floor surface at NRC .25 (minimum). Acoustic tile is also required to within 4 feet of the floor.	
8. Adequate lighting.	**8.** Lighting shall be specially engineered. Low levels of lighting may be required to permit observation of luminous panels without reflected glare or undesirable contrasts in brightness. Separately controlled luminaires shall be provided for normally lighted operations and for cleaning, with an ambient level of 70 footcandles from fluorescent fixtures.	**8.** For further information on quality lighting design using the ESI concept, see Vol 2, SB2, Electrical--Lighting.

requirements	criteria	commentary
9. Controlled environment for proper operation.	**9.** Maintain 70°F ($\pm 2^{\circ}$) and 50 percent relative humidity (± 5 percent continuously. Provide 5 cubic feet per minute per person outside air ventilation rate or the outside air quantity necessary to maintain a room pressurization requirement of .05 to .10 water gage.	**9.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
10. Electrical power.	**10.** Provide 120/208 electrical service and 120-volt outlets--one receptacle for every 10 linear feet of wall. Outlets for equipment should be available under the raised floor as per layout. Electrical power must fall within the 10,000 to 500,000 watt range, with frequency levels at 50 to 60 hertz ± 5 percent.	**10.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
11. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	**11.** Vaulted enclosure walls--2 hour (minimum) fire-rated, shielded construction. Interior doors in vaulted walls--1.5-hour fire-rated doors; shielded doors and frames. Interior finish--Class A or B only. Automatic fire detection--Local alarm. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility. Manual emergency equipment power shut-off at exits. Under raised floor area--Automatic fire detection: Local alarm. Automatic Halon 1301 suppression system if required for cross-zoned or matrix detection. Sprinkler and Halon systems are not normally installed in the same areas.	**11.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information. Automatic fire suppression may include Halon 1301 where specifically justified

guidance



12 -- speaker in ceiling

guidance

1. Equipment expansion

It is advisable to arrange equipment in the equipment room such that future expansion of the building will not necessitate complete rearrangement. (2) 5-21

Approximately 3 feet of clearance space, as a minimum, should be allowed in front of and to the rear of an equipment bay. If a bay does not permit rear access to equipment, the bay can be installed with no clearance on the back side, that is, against a wall or back-to-back with other bays, unless ventilation requirements are compromised. (2) 5-21

5. Raised floor system

Most equipment that requires significant cooling to maintain communication operations should be located on raised floors for maximal use of coupled air directly through the cabinets. Cooling air at 60^{O}F supplied directly into the base of the transmitters will leave the top at approximately 72^{O}F. Thus, when the air exits the equipment, it is at a more comfortable temperature for persons working in the space.

8. Control area

Light fixtures should provide an approximate uniform lighting intensity of 70 footcandles and should be equipped with light control lenses or specular parabolic louvers to minimize glare on working surfaces. Lights over the area in which the control console is located shall be provided with wide-range (100:1) dimming control. (23)12

Equipment area

Fixtures should be arranged above the operating aisles and should run parallel to equipment row arrangement. They should be located so the light does not cast shadows or reflections on the front of the technical equipment and so light is not obstructed by the cable trays. Flush-mounted fluorescent lighting fixtures are recommended, and they shall be equipped with integral RFI filters (GE no. 89G635, Sprague IF-37, or equivalent). The lights shall not interfere with access to the cable trays or equipment. (23)12 Portable task lighting should also be supplied for the equipment area at 70 to 100 footcandles.

9. Protection from moisture migration

Operating spaces that contain electronic equipment usually require close temperature and humidity control. Vapor barriers placed under floor slabs and roofing usually prevent moisture migration into and out of interior electronic equipment spaces. Additional protection must be provided if exterior walls form part of the equipment space. (92)12.1-13

See also Vol 2, SB2, Special Mechanical.

guidance

Mechanical

The recommended operating temperatures and humidity conditions should be obtained from the manufacturers of the communications and data processing equipment and should be used in designing the environmental control system.

Air-conditioning

Continuous, reliable operation of any computer system depends on an efficient, well designed, properly controlled air-conditioning system. Inadequate cooling contributes as much to failure as poorly regulated power. (74) 4-17

Even though certain individual units can operate outside the limits of the overall specifications, overall environmental requirements are dictated by the most restrictive unit of the system. The computer system's requirements are the major considerations; however, good design will also consider personnel comfort. (74) 4-17

An air-conditioning system for a computer installation differs from ordinary comfort air-conditioning in the following ways. (74) 4-17

- Heat dissipation by computers is relatively constant; therefore, cooling is required year-round.
- The computer room sensible heat ratio is near unity because heat dissipated by the computer system is all sensible.
- Above-average air filtration is required to prevent errors caused by dust particles on magnetic tapes.
- The number of air changes per hour varies between 30 and 60 because of the computer equipment's high heat dissipation.
- Humidity control is required year-round to maintain necessary conditions in the computer room. However, introducing water vapor into the airstream for humidification is not recommended for electronic equipment areas because water vapor can damage electronic components. (40) 7-3

Temperature and humidity recording instruments

Recording instruments are needed to provide a continuous record of temperature and humidity in the machine area. Also, if the air-conditioning requirements are not met, a record must be available to indicate the extent and duration of the undesirable condition and indicate whether a drying-out period is required. In some cases, this may save machine shutdown time. (74) 4-25

The record of temperature and humidity can be used to: (74) 4-25

guidance

- Insure the air-conditioning system continues to perform its job properly. Installation errors and loss of efficiency due to malfunction of some air-conditioning system part can be detected quickly.
- Determine if a mandatory drying-out period is needed when humidity limitations are exceeded. Drying out may be necessary if the excess humidity occurs either during periods of actual operation or while the machine is shut down and unattended. The extent and duration of excessive humidity determines the length of the drying-out period.
- Determine if the environment meets requirements for the machine.

A visual or audible signaling device is desirable in the recording instrument. This is to provide visual or audible indication that temperature or humidity in the computer area is nearing the maximum limit.

Direct-reading instruments with a 7-day electric-drive chart are sometimes used in installations to monitor ambient room conditions. The recorder is usually located at a representative spot in the room and adjacent to the control devices.

For monitoring underfloor air conditions, a remote indicating instrument is recommended. This is usually a 7-day electric-drive chart and can be the wet-and-dry-bulb or electronic type if direct reading is not available. The recording instrument can be located on the wall in the operations room, in the mechanical equipment room, or in any other location convenient to the building engineer.

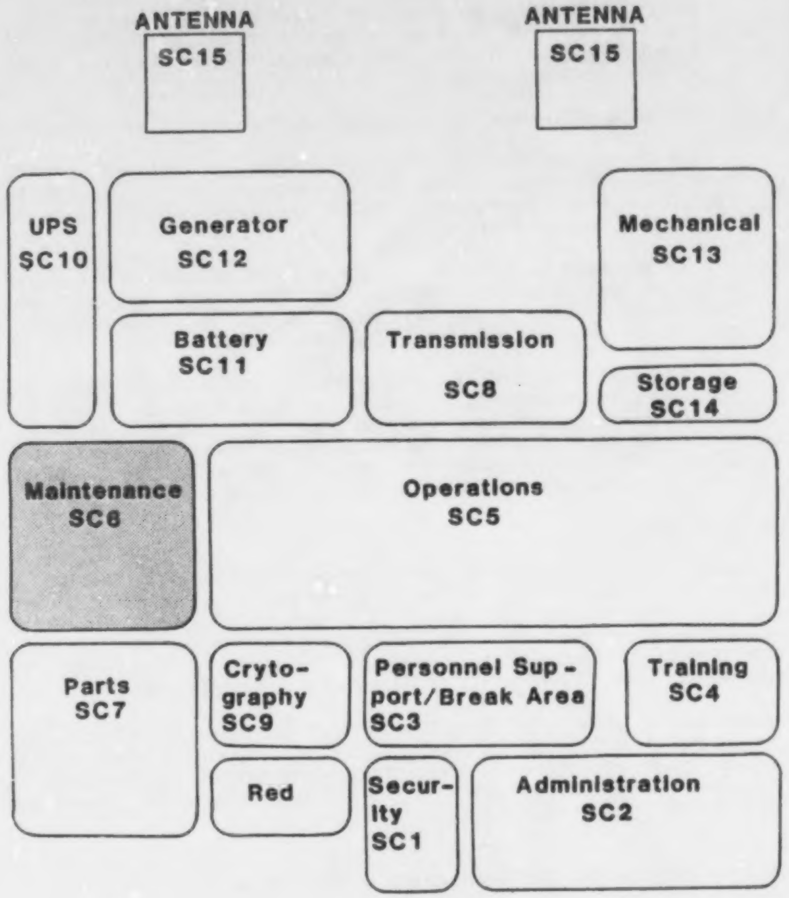
10. Electrical

Consider providing a flexible system that will meet the facility's future requirements. Electronic equipment is constantly being upgraded, modified, and replaced. Bus duct systems and cable trays may prove to be most flexible for areas in which new equipment is expected or that may have frequent modification. (5) 3-4-8. A recommended expansion capacity of 40 percent is usually provided.

Specifically refer to the "Electrical" portion of "Issues and Assumptions" portion of SB2, Vol. 2, for information relative to host nation power requirements. Additional information may be found in "guidance" of SB2 with respect to the standard frequencies and voltage levels used by various nations.

Provide host nation standard outlets if applicable.

MAINTENANCE SC6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SC6
Operations
SC5
Parts
SC7
Cryto-
graphy
SC9
Personnel Sup-
port/Break Area
SC3
Training
SC4
Red
Secur-
ity
SC1
Administration
SC2

function

This area is for assigned personnel and the shift supervisor who repair, clean, and test communication equipment.

policy/sop

1. It is desirable to provide a separate maintenance room with space for repair activities and the associated test equipment and tools. The space required will, of course, depend on the amount of C-E equipment installed, the number of maintenance personnel involved, and requirements for stocking spare parts.

2. To test and service a microwave communications system properly, maintenance personnel should have a thorough understanding of the equipment's physical makeup, operational characteristics, capabilities, and limitations, and should be familiar with the circuit theory of operation. It is equally important that the proper test equipment be available to these personnel. As the area of maintenance progresses from onsite field maintenance to depot maintenance, the quantity and requirements of the associated test equipment will increase, necessitating improved facility responsiveness. (70) 7-51

best copy available

issues and assumptions

activities

1. Inspecting and diagnosing equipment and parts.
2. Completing preventive and unscheduled maintenance.
3. Assembling electronics.
4. Testing electronics.
5. Securing storage of parts and equipment.
6. Maintaining records on parts and equipment.
7. Writing and typing reports, PMI 349's, and equipment historical records.

personnel

1. Shift supervisor.
2. One or two specialists.

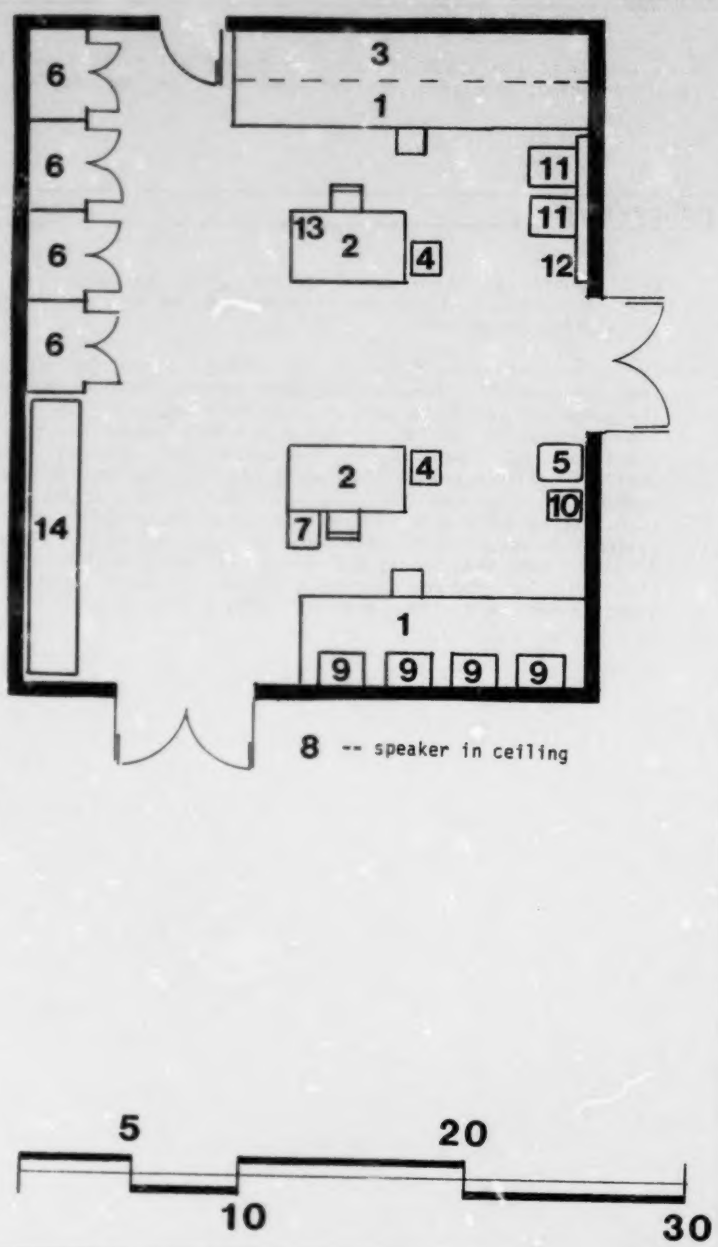
equipment *

1. Two electronic workbenches with stools.
2. Two desks with chairs, one with a typing stand.
3. Shelving over workbench for publications.
4. File cabinet.
5. Portable vacuum cleaner to clean equipment parts. If compressed air blower unit is supplied instead, use 30 pounds per square inch maximum to prevent damage to parts. (Use with a dust collector.)
6. Locked storage cabinets secured to wall for special electronic equipment.
7. Typewriter or word processor.
8. Intercom speaker.
9. Wall-mounted test equipment over workbench.
10. Portable power supply test set.
11. Two scope carts.
12. Multiboard (24 by 48 inches).
13. Telephone.
14. Shelving for inactive equipment storage.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for inspection, disassembly, and reassembly of sensitive electronic equipment. Space must also accommodate administrative, tool, and part needs.	**1.** Provide approximately 500 square feet.	
2. A secure, controlled area.	**2.** The room should be lockable when unstaffed.	**2.** See Vol 2, SB7, Security (Zone 3) for more information.
3. Interior finishes suitable for durability, maintenance, and room function.	**3.** Floor--Vinyl asbestos tile. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	**3.** See also Vol 2, SB2, Interior Construction and Finishes.
4. Acoustical isolation and attenuation to eliminate C-E equipment noise to help personnel concentrate when they work on electronic components.	**4.** The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC. 90, floor surface at NRC .50, and divider partitions (if used) at .85.	
5. Adequate lighting.	**5.** Fixtures should provide 70 footcandles for ambient lighting and 150 footcandles for task lighting.	**5.** For further information on quality of lighting design using the ESI concept, see Vol 2, SB2, Electrical Lighting.
6. Thermal regulation and other comfort features for occupants.	**6.** Regulate temperature at 68°F (heating), 78°F (cooling), with a 5-cubic feet per minute per person outside air ventilation rate. Provide a chair with seat height adustment, casters, swivel, and independent backrest adjustment.	**6.** See Also Vol 2, SB2, Communication Station Buildings--Mechanical.
7. Electrical power.	**7.** Install 120/208 electrical service. 120-volt receptacles should be located for convenience at all workstations and workbenches at the appropriate height for every 10 linear feet of wall. Provide four duplex outlets at each workbench. All equipment and workbenches must be grounded. Frequency levels should be 50 to 60 hertz ± 5 percent.	**7.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
8. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	**8.** Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly scaffed station outside the facility.	**8.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance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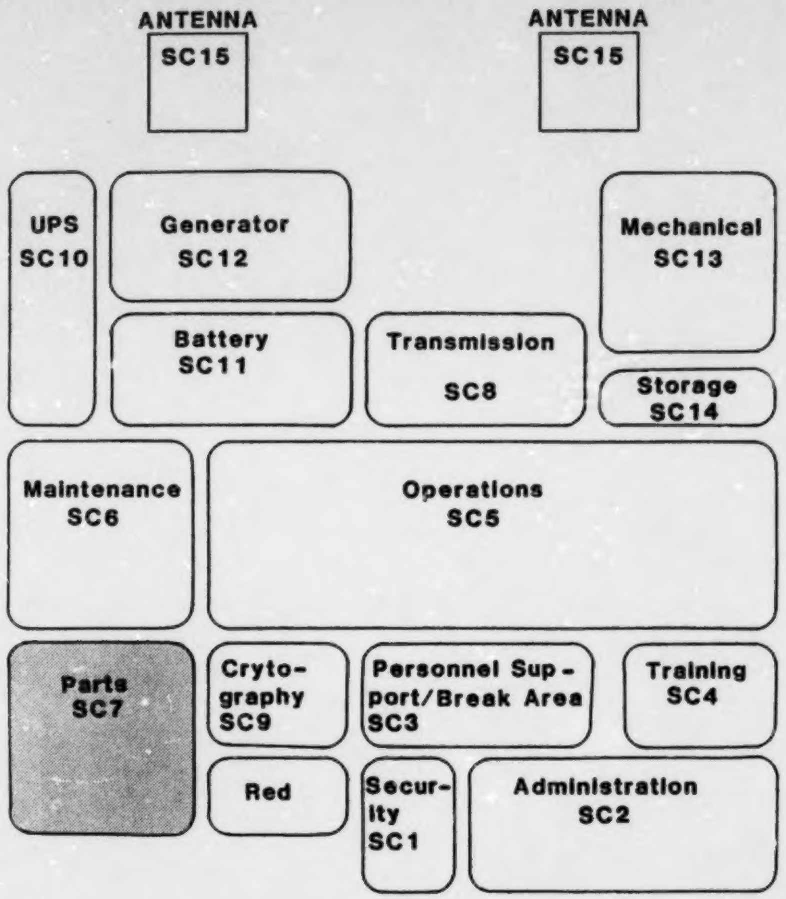
guidance

PARTS SC7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SC14
Maintenance
SC6
Operations
SC5
Parts
SC7
Cryto-
graphy
SC9
Personnel Sup-
port/Break Area
SC3
Training
SC4
Red
Secur-
ity
SC1
Administration
SC2

function

This element is the space required to manage all parts supply operations: ordering, receiving, storage, inventory, and security.

policy/sop

1. Requirements for spare parts storage space are determined by the type of equipment at the installation and the level of maintenance to be performed onsite.

2. During preventive maintenance inspections, it may be noticed that some components' performance has deteriorated. Rather than wait for the component to become weaker or to fail completely and cause system interruption, it is considered good maintenance practice to replace the faulty parts during the inspection. Although components would be replaced before their full service life has been realized, service interruptions could be avoided. This practice would, in turn, increase the expected replacement parts cost for an operating system; however, the increase would be justified on the basis of increased system reliability and savings for additional manpower costs that would be incurred in making special trips to unattended stations to restore system operation. (70) 7-49

issues and assumptions

activities

1. Developing parts order lists and working with station Central Supply Office.
2. Receiving, unpacking, shelving of prescribed load list and facility supply parts.
3. Packing and shipping repairable items.

personnel

1. One supply specialist.

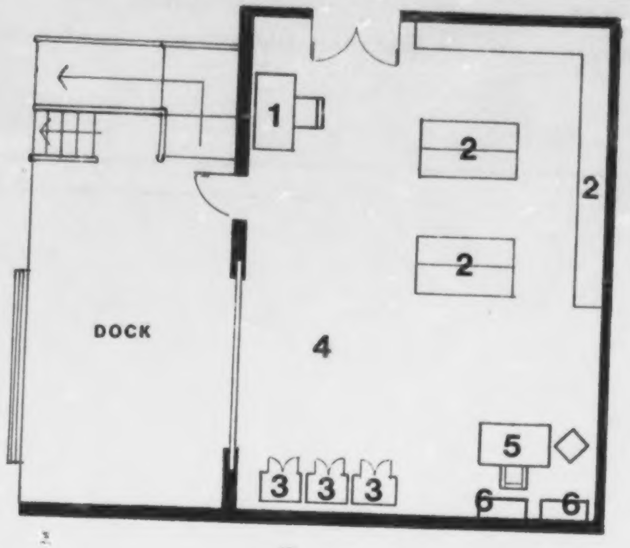
equipment *

1. Table (30 by 60 inches) with chair.
2. Shelving--30 linear feet, floor-to-ceiling type.
3. Three locked cabinets (24 by 36 inches).
4. Open area (100 square feet) for unpacking orders.
5. Desk with chair for parts ordering, microfiche unit.
6. Bookcase for supply manuals--3 to 4 linear feet.
7. Intercom speaker.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for ordering, receiving, and storing C-E equipment. Space must include an open area to facilitate easy receiving of large equipment and supply orders.	1. Provide approximately 1000 square feet to accommodate storage shelves and to leave an open area for receiving shipments of parts and supplies.	
2. A secure environment.	2. This area must be lockable when unstaffed. Provide an intrusion alarm system.	2. See Vol 2, SB7, Security (Zone 3), for more information.
3. Interior finishes suitable for durability, maintenance, and room function.	3. Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	3. See also Vol 2, SB2, Interior Construction and Finishes.
4. Acoustical isolation and attenuation: Acoustical comfort for a nondisruptive environment.	4. Adjacent room walls should limit sound transmission to 40 decibels.	
5. Adequate lighting.	5. Lighting should be: 20 footcandles (ambient) and 70 footcandles (task).	
6. Environmental control for proper storage of electronic equipment.	6. Regulate temperature at 68°F (heating), 78°F (cooling), with a 5-cubic feet per minute per person outside air ventilation rate.	6. See also Vol 2, SB2, Communication Station Buildings--Mechanical.
7. Electrical power.	7. Supply 120/208 electrical service. 120-volt receptacles should be located for convenience at all workstations and workbenches at the appropriate height and for every 10 linear feet of wall. Required frequency levels are 50 to 60 hertz ± 5 percent.	7. See also Vol 2, SB2, Communication Station Buildings--Electrical.
8. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	8. Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	8. See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



7 -- speaker in ceiling

guidance

1. Location

Locate the parts area between the exterior receiving dock and the maintenance room.

Provide an open area for unpacking equipment before it is moved into operation or equipment rooms.

A loading dock should be designed for a minimum load of 250 pounds per square foot and should provide enough room to maneuver equipment.

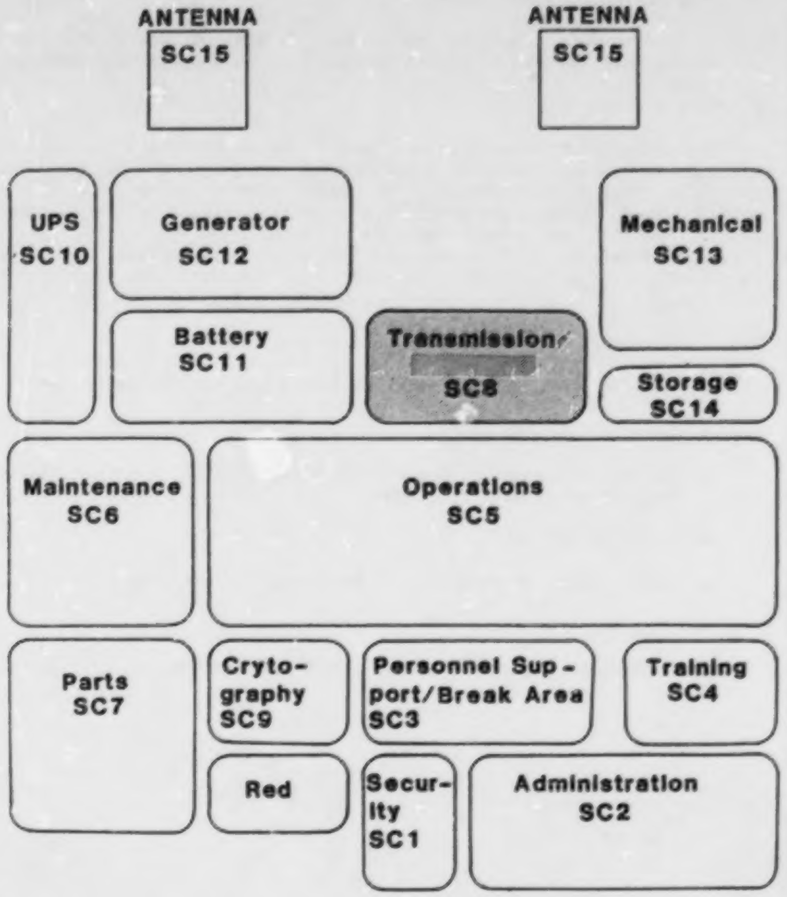
2. Door security

Maintenance/utility doors not permitting entry to administrative/-operational spaces should be secured with heavy cylindrical case lock and latch sets in conformance with Federal Specification FF-H-106 and with Builders Hardware Manufacturers Association Standard 601. Doors and hatches that are externally accessible and lead to critical utilities should be secured with padlocks and hasps in conformance with Military Specification MIL-P-43607 instead of or in addition to the cylindrical case or bored locksets specified above. (5) 3-5-9

The hardware set for secure doors should be:

- 1/8-inch-thick drill-resistant hard plate for inside of door
- Secured-type hinges
- Cypher lock with an electronic access control, electric strike, and emergency battery standby
- Combination lock
- Door closer (on each leaf if pair door is required)
- Wide-angle peephole
- Foot bolts and pull-chain bolt for inactive leaf of pair doors.

TRANSMISSION SC8


ANTENNA
SC15
ANTENNA
SC15
UPS
SC10
Generator
SC12
Mechanical
SC13
Battery
SC11
Transmission
SC8
Storage
SC14
Maintenance
SC6
Operations
SC5
Parts
SC7
Cryto-
graphy
SC9
Personnel Sup-
port/Break Area
SC3
Training
SC4
Red
Secur-
ity
SC1
Administration
SC2

function

This area contains the equipment that transmits DCS communications and other information.

policy/sop

issues and assumptions

1. Automated recordkeeping

CRTs with hardline printers can streamline paperwork by storing all circuit history files on disk. This will allow more rapid troubleshooting in-house.

2. Electromagnetic compatibility (2) 5-43

Electromagnetic compatibility (EMC) is a complex subject, so that specialists often must perform the type of EMC study needed to insure the equipment or equipment layout produces no interferences or radiation hazard.

DOD is working on new regulations to control permissible levels of EM pollution of the frequency spectrum. This work reflects the concern for environmental protection. Radiation hazards also are being regulated through concern for occupational safety. Engineering agencies working for the Government must therefore know the legal and regulatory aspects of EMC and radiation hazards to meet these requirements.

Military specifications on EMC such as MIL-STD-461, -462, and -463 are intended to control and achieve an acceptable quality in the development of new communications equipment. They do not eliminate the need for EMC engineering in facility design. In addition to equipment quality, the frequency selection, nearness to other facilities and, to some extent, the facility design itself are variables in the interference generation problem. (2) 5-43

3. Determining the correct shielding procedure

A comprehensive approach to the shielding of equipment from radio-frequency interference (RFI) or TEMPEST involves (a) a building layout to optimize inherent facility shielding conditions, (b) suitable location of all electronic equipment and signal cables, and (c) selection of effective shielding materials and construction components.

See Vol 2, SB4, for additional guidance information.

activities

1. Monitoring transmission equipment.
2. Testing and maintaining transmission equipment.
3. Receiving and processing outage reports.
4. Logging in transmission data.
5. Recording maintenance work.
6. Conducting training sessions at console.

personnel

equipment *

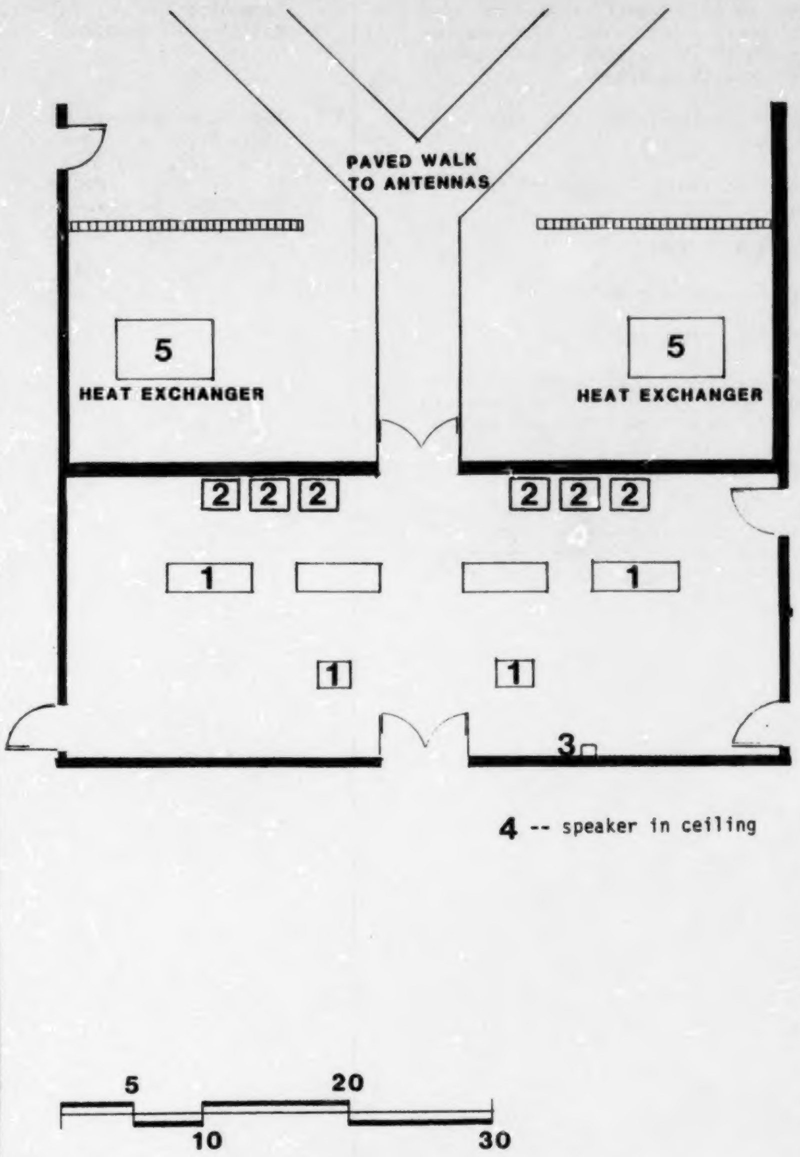
1. Transmission equipment.
2. Carts for storage.
3. Telephones.
4. Intercom speaker.
5. Heat exchanger

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Adequate space for layout of transmission equipment. Enough room and storage space to accommodate inspection and testing of communication equipment.	1. Approximately 500 to 1000 square feet are needed to accommodate the transmitter bays. Provide at least a 48 inch workspace behind all equipment for inspection, testing, and repair.	
2. Adequate space for layout of heat exchanger equipment adjacent to the transmission room.	2. Approximately 300 square feet per heat exchanger are needed. Provide a reinforced concrete slab to support the exchanger. A permanent covering is needed for protection against weather.	
3. Secure environment for C-E equipment.	3. Provide a cipher lock and intrusion alarm system on the exterior door.	
4. RFI shielding.	4. Shielding is required for electrical and electronic equipment to prevent the propagation of interference and to protect against interference propagated by other electronic devices. (15a)7	4. See also Vol 2, SB4, Grounding, Bonding, and Shielding along with SB5, EMP/HEMP Protection.
5. Raised floor system.	5. Raised or false floors are necessary for proper cooling of the equipment.	5. See also Vol 2, SB2, Communication Station Buildings--Architectural.
6. Interior finishes suitable for durability, maintenance, and room function.	6. Floor--Vinyl asbestos tile panels. A raised floor system shall be used over a concrete floor with a dust-on finish with hardener. See Vol 2, SB2--Interior Construction. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster and acoustic tiles to within 4 feet of the floor. Ceiling--Acoustic tile.	6. See also Vol 2, SB2, Interior Construction and Finishes.
7. Acoustical isolation/attenuation for variable noise levels produced by electrical equipment.	7. Adjacent room walls should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum) and floor surface at NRC .25 (minimum). Acoustic tile is also required to within 4 feet of the floor.	
8. Adequate lighting.	8. Ambient lighting should be 20 footcandles. For testing and inspection, use 70- to 100-footcandle task lighting.	
9. Proper environmental control for electronic equipment.	9. The environment temperature should be at 73^{o}F ($\pm 2^{o}$) and 50 percent relative humidity ($\pm$ 5 percent). Transmission area should have filtered air. (See MIL-HDBK 411A.)	9. See also Vol 2, SB2, Communication Station Buildings--Mechanical.

requirements	criteria	commentary
10. Electrical power.	**10.** Provide 120/208 electrical service. Electric power may fall within the 10,000- to 50,000-watt range. Voltages are required at 50/60 hertz + 5 percent. Provide one 120-volt outlet for every 10 linear feet of wall and as required for coordination with equipment.	**10.** See also Vol 2, SB 2, Communication Station Buildings--Electrical.
11. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**11.** Vaulted enclosure walls--2-hour minimum fire-rated construction; shielded construction. Interior doors in vaulted walls--1.5-hour fire-rated doors; shielded doors and frames. Interior finish--Class A or B only. Automatic fire detection--Local alarm. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility. Manual emergency equipment power shut-off at exits. Under raised floor area automatic fire detection--Local alarm; automatic Halon 1301 suppression system if cross-zoned or matrix detection is required. Sprinkler and Halon systems are not normally installed in the same areas.	**11.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



4 -- speaker in ceiling

guidance

2. Heat exchanger area

The heat exchanger space must accommodate nitrogen, glycol, and demineralized water. Adequate weather protection and lighting must be provided.

3. Door access

The doors shall be able to be held in the open position easily (against closure unit pressure) for moving equipment through. They should be selectable disconnect type--not mechanical.

5. Raised floor systems

Most equipment that requires significant cooling to maintain communication operations should be located on a raised floor system so that maximum flow of cooled air directly through the cabinets is possible. Cooling air (60°F) supplied directly into the base of the transmitters will leave the top at approximately 72°F. When the air exits the equipment, it is at a more comfortable temperature for personnel working in the space.

8. Equipment area

Fixtures should be arranged above the operating aisles, running parallel to equipment row arrangements. They should be located so as not to cast shadows or reflections on the front of the technical equipment or to be obstructed by the cable trays. Flush-mounted fluorescent lighting fixtures are recommended, and they shall be equipped with integral RF interference filters (GE no. 89G635, Sprague IF-37, or equivalent). Lights shall not interfere with access to the cable trays or equipment. (23)12 Portable task lighting should also be supplied for the equipment area at 70-to 100 footcandles.

9. Protection from moisture migration

Operating spaces that contain electronic equipment usually require close control of temperature and humidity. Vapor barriers placed under floor slabs and incorporated into roofing usually prevent moisture migration into and out of interior electronic equipment spaces. However, additional protection must be provided when exterior walls form part of the equipment space. (92)12.1-13

See also Vol 2, SB2, Special Mechanical.

guidance

Air-conditioning

Continuous, reliable operation of computer systems depends on an efficient, well designed, properly controlled air-conditioning system. Lack of adequate cooling contributes as much to failure as poorly regulated power. (74) 4-17

Even though certain individual units can operate outside the limits of the overall specifications, the system's environmental requirements are dictated by its most restrictive unit. Computer system requirements are the major considerations in air-conditioning system design. However, good design will also consider personnel comfort. (74) 4-17

An air-conditioning system for a computer installation differs from ordinary comfort air-conditioning in the following ways: (74) 4-17

- Heat dissipation by the computers is relatively constant; therefore, year-round cooling is required.
- The computer room sensible heat ratio is near unity because all heat dissipated by the computer system is sensible.
- Above-average air filtration is required to prevent errors caused by dust particles on magnetic tapes.
- The number of air changes per hour varies between 30 and 60 because of the computer equipment's high heat dissipation.
- Year-round humidity control is required to maintain necessary conditions in the computer room. However, introducing water vapor into the airstream for humidification is not recommended in electronic equipment areas because this can cause damage. (40) 7-3

Temperature and humidity recording instruments

Recording instruments are required to provide a continuous record of temperature and humidity in the machine area. Also, if the air-conditioning requirements are not met, a record is available to indicate the extent and duration of the undesirable condition and to show whether a drying-out period is required. In some cases, this may save machine shutdown time. (74) 4-25

The record of temperature and humidity can be used to: (74) 4-25

- Insure that the air-conditioning installation continues to perform its job properly. Installation errors and loss of efficiency due to malfunction of some air-conditioning system part can be detected quickly.
- Determine if a drying-out period is necessary when humidity limitations are exceeded. Drying-out may be needed if the excess humidity occurs either during actual system operation or when the machine is shut down and unattended. The extent and duration of the excess humidity is used to determine the length of the drying-out period.
- Determine if the environment in the area meets the requirements for the machine.

guidance

A visual or audible signal in the instrument is desirable to indicate when temperature or humidity in the computer area is nearing maximum limit.

Direct-reading instruments with a 7-day electric-drive chart are sometimes used to monitor ambient room conditions in installations. The recorder is usually located at a representative point in the room and adjacent to the control devices.

A remote indicating instrument is recommended for monitoring the underfloor air. This is usually a 7-day electric-drive chart and can be the wet-and-dry bulb or electronic type if direct reading is not available. This instrument can be located on the wall in the room, in the mechanical equipment room, or at any other location convenient to the building engineer.

guidance

9. Supply/exhaust system

Air-conditioning input to transmitters is dedicated to each unit. Input is from below, as shown in Figure SC-1. An alternative source of air should also be available.

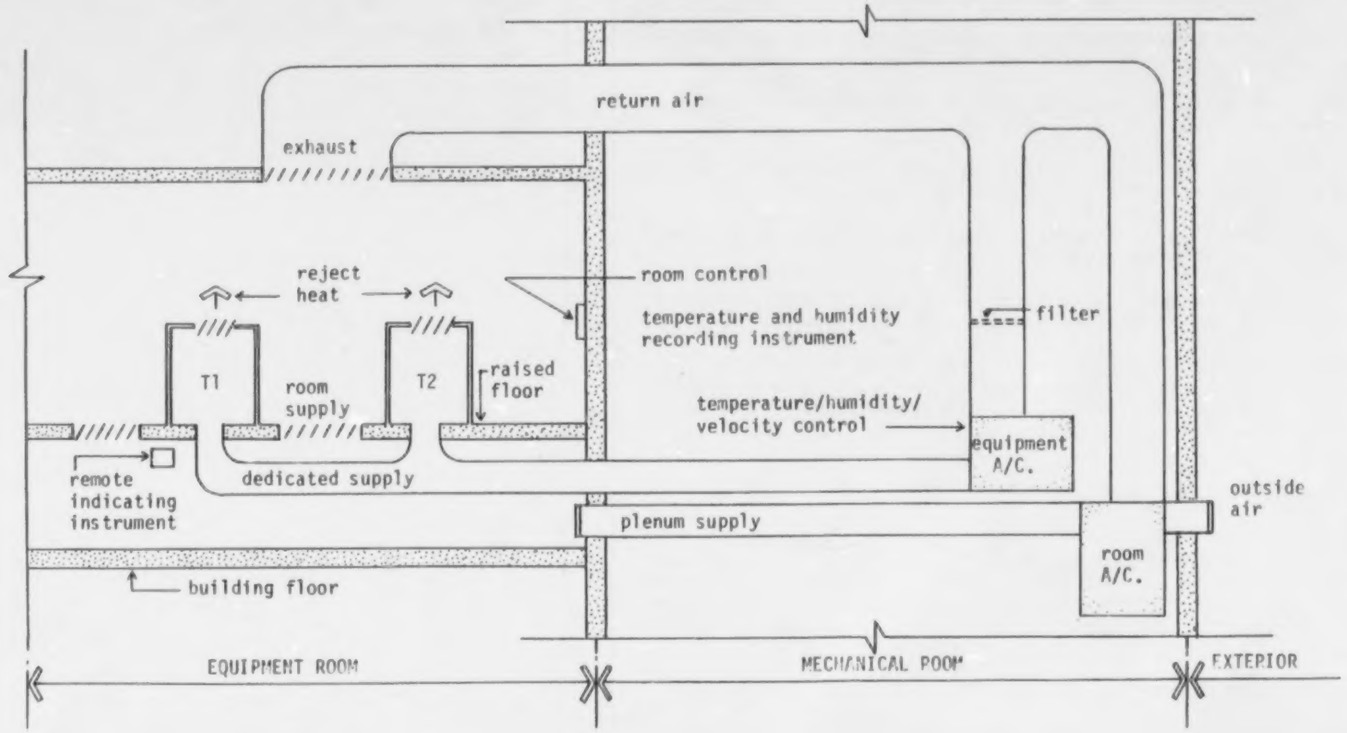
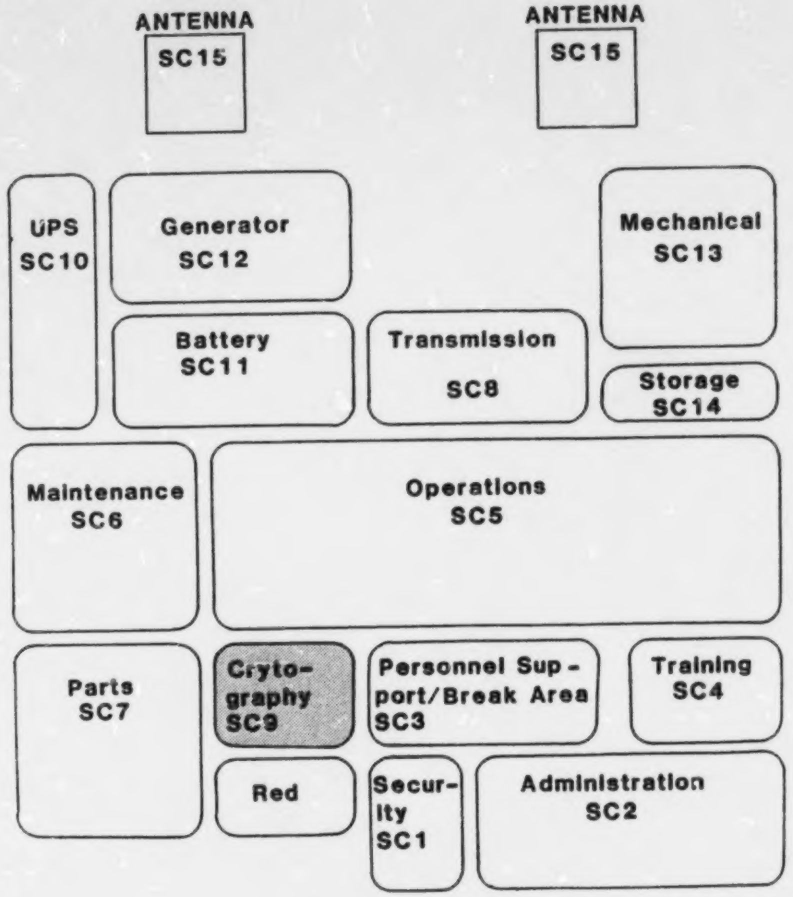

return air
exhaust
reject heat
room control
temperature and humidity recording instrument
filter
T1
room supply
T2
raised floor
temperature/humidity/velocity control
equipment A/C.
remote indicating instrument
dedicated supply
outside air
plenum supply
room A/C.
building floor
EQUIPMENT ROOM
MECHANICAL ROOM
EXTERIOR

FIGURE SC-1. AIR-CONDITIONING INPUT TO TRANSMITTERS.

guidance

guidance

CRYPTOGRAPHY SC9


ANTENNA
SC15
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UPS
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Generator
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Personnel Sup-
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Training
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Administration
SC2

function

The cryptography area provides a secure place for encryption or decryption of information that passes through the communication facility.

policy/sop

1. The national policy objective is to insure that national security information is not lost through unintentional emanations. To achieve this, equipment should be designed to meet TEMPEST requirements and should be tested to verify compliance with TEMPEST specifications. See Vol 2, SB4, for additional guidance information.

2. The RED/BLACK concept is the basis for the facility criteria development presented here. The RED/BLACK concept dictates that electrical and electronic circuits, components, equipment, systems, and other items that handle national security plain language information in electrical signal form (RED) be separated from those handling encrypted or unclassified information (BLACK). Under this concept, RED and BLACK terminology is used to clarify specific criteria relating to the difference between such circuits, components, equipment, and systems, and the area in which they are contained.

issues and assumptions

1. Proper location for cryptographic equipment

Locate sensitive and critical equipment as close to the core of the structure as operational requirements permit. In addition, identify the location of likely sources of interference such as power substations, engine-generators, and RF transmitters; maximize the separation between such sources and potentially susceptible equipment or systems. (15b) 1-173

2. Electromagnetic compatibility (2) 5-43

Electromagnetic compatibility (EMC) is a complex subject, so that specialists often are needed to perform the type of EMC study needed to insure that the equipment or equipment layout produces no interference or radiation hazard.

DOD is working on new regulations to control permissible levels of EM pollution of the frequency spectrum. This work reflects the concern for environmental protection. Radiation hazards also are being regulated through concern for occupational safety. Engineering agencies working for the military must therefore know the legal and regulatory aspects of the EMC and radiation hazards to meet these requirements.

Military specifications on EMC such as MIL-STD-461, -462, and -463 are intended to control and achieve an acceptable figure of merit or quality in the development of new communications equipment. They do not eliminate the need for EMC engineering in facility design. In addition to equipment quality, the frequency selection, nearness to other facilities, and, to some extent, the facility design itself are variables in the interference generation problem. (2) 5-43

3. Correct shielding procedure

A comprehensive approach to shielding equipment from radiofrequency interference (RFI) or TEMPEST involves (a) a building layout to optimize inherent facility shielding conditions, (b) suitable location of all electronic equipment and signal cables, and (c) selection of effective shielding materials and construction components. See Vol 2, SB4, for additional guidance information.

activities

1. Inspecting and diagnosing equipment and parts.
2. Doing complete preventive and unscheduled maintenance.
3. Assembling electronics.
4. Testing electronics.
5. Insuring secure storage of parts and equipment.
6. Maintaining records on parts and equipment.
7. Writing and typing reports: 349s, and equipment historical records.
8. Monitoring CRYPTO sync panel.
9. Notifying contractor on CRYPTO when problems arise.

personnel

1. Two crypto technicians.

equipment *

1. Two electronic workbenches with stools.

2. Shelving over workbench for publications manuals.

3. Locked storage cabinets secured to wall for special electronic equipment.

4. Red Patch Bay.

5. Black Patch Bay.

6. Telephone.

7. Filesafe (1) for records.

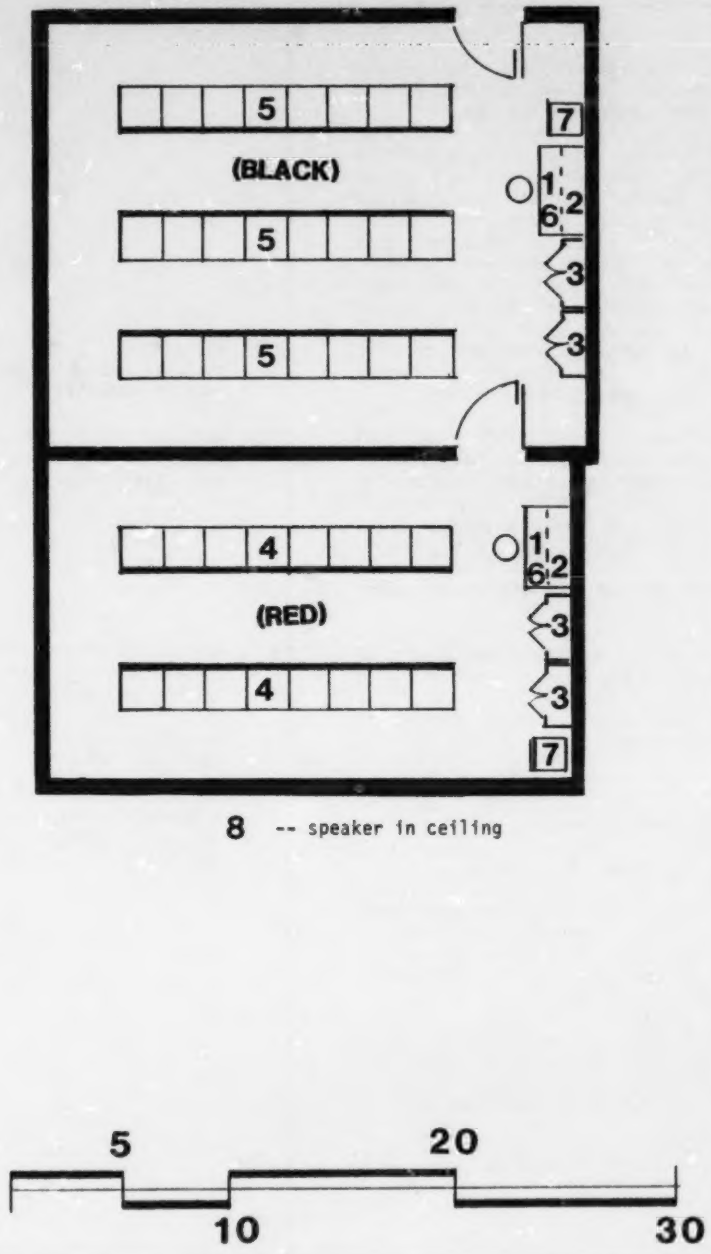
8. Intercom speaker.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Adequate space to accommodate the cryptologic function.	**1.** Approximately 1000 square feet are required to provide space for two personnel and the required cryptography equipment.	
2. Security.	**2.** It must be lockable when unstaffed by providing a cipher lock and intrusion alarm system. In addition to physical protection by walls and doors, the ceiling and air-conditioning ducts must be intrusion-proof. For RED/BLACK security, the installation shall conform to MIL-HDBK-232.	**2.** See Vol 2, SB7, Security (Zone 3), for more information.
3. Communication lines for emergency operations.	**3.** The telephone system must be coordinated with key lines (pre-designated personnel).	
4. RFI/TEMPEST shielding.	**4.** Shielding is required for electrical and electronic equipment to prevent it from propagating interference and to protect it against interference propagated by other electronic devices (15a)7 The term "TEMPEST" flags the system as one processing National Security related information and establishes the need for additional, site-specific alterations and improvements to the facility.	**4.** See Vol 2, SB4, Grounding, Bonding and Shielding, along with SB7, Security Systems, for more information.
5. EMP/HEMP shielding.	**5.** Shielding is necessary for survivability and uninterrupted functioning when the facility is subjected to EMP and HEMP. Protective measures are based on intercepting the incident energy and dissipating it or reflecting it away from the threatened device, equipment, or facility.	**5.** See Vol 2, SB5, EMP/HEMP Protection, for more information.
6. Interior finishes suitable for durability, maintenance, and room function.	**6.** Floor--Vinyl asbestos tile panels. A raised floor system shall be used over a concrete floor with a dust-on finish that contains a hardener. See Vol 2, SB2, Interior Construction. Base--Glazed structural units, rubber vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster and acoustic tiles to within 4 feet of the floor. Ceiling--Acoustic tile.	**6.** See also Vol 2, SB2, Interior Construction and Finishes.

requirements	criteria	commentary
7. Acoustical isolation/attenuation to provide comfort for a nondisruptive environment.	**7.** The walls surrounding the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .90, floor surface at NRC .50.	
8. Adequate lighting.	**8.** Light fixtures should provide an approximate uniform light intensity of 70 footcandles and should be equipped with light control lenses or specular parabolic louvers to minimize glare on working surfaces. Fixtures shall also be equipped with integral RF interference filters (GE no. 89G635, Sprague IF-37, or equivalent). The work area shall also be equipped with adjustable task lighting.	
9. Thermal comfort.	**9.** Temperature should be kept at 68°F (heating) and 78°F (cooling). A 5-cubic feet per minute per person outside air ventilation rate should be maintained.	**9.** See also Vol 2, SB2, Communication Station Buildings--Mechanical
10. Electrical power.	**10.** Power should be supplied by a 120/208 electrical service. A 120-volt receptacle should be installed for each workstation at a convenient height and/or for every 10 linear feet of wall. Electrical power must fall within the 10,000- to 500,000-watt range. Frequency levels must be at 50 to 60 hertz ± 5 percent. Provide line filters for RFI on all electrical power lines.	**10.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
11. Fire protection/life safety criteria are based on the assumption that this facility houses critical equipment and data, which creates a severe strategic fire loss potential.	**11.** Vaulted enclosure walls--2-hour minimum fire-rated construction; shielded construction. Interior doors in vaulted walls--1.5-hour fire-rated doors; shielded doors and frames. Interior finish--Class A or B only. Automatic fire detection--Local alarm. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or to constantly staffed station outside the facility. Manual emergency equipment power shut-off at exits. Under raised floor area automatic fire detection--Local alarm; automatic Halon 1301 suppression system if cross-zoned or matrix detection is required. Sprinkler and Halon systems are not normally installed in the same areas.	**11.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information. Automatic fire suppression may include Halon 1301 where specifically justified

guidance



5
(BLACK)
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(RED)
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8 -- speaker in ceiling
5
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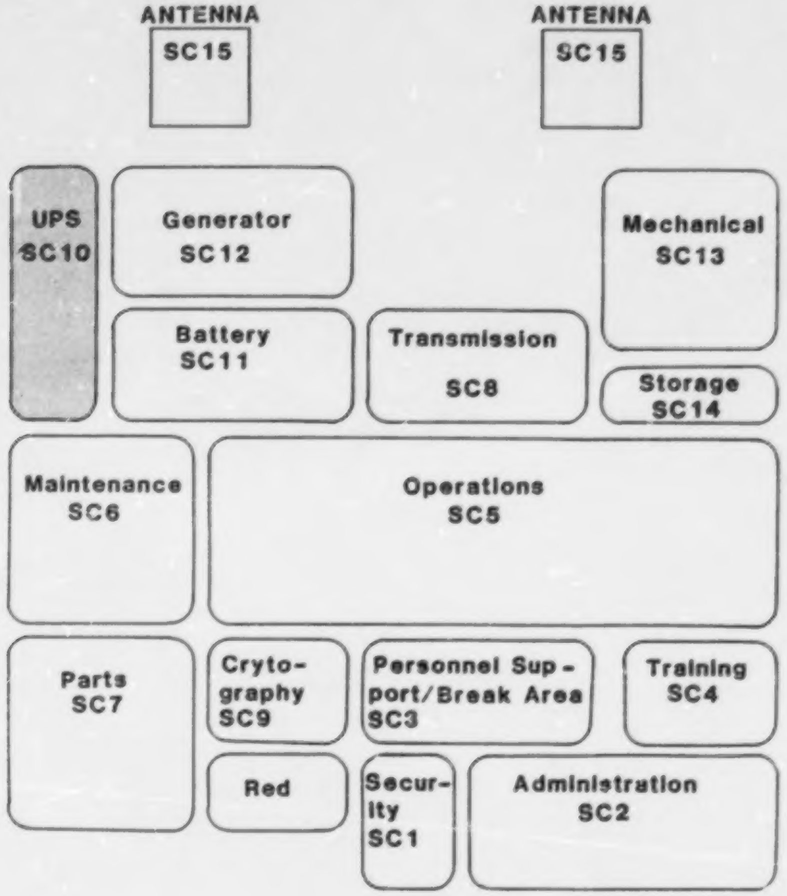
10
30

guidance

guidance

guidance

UPS SC 10


ANTENNA
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function

An uninterruptible power supply (UPS) is designed to provide continuous power, without delay or transients, to the critical load.

policy/sop

UPS are characterized by their ability to condition primary or auxiliary power to precise, high-quality power as required by the C-E equipment. UPS maintain continuous power during periods of transfer from one power source to another or for a period long enough to allow for an orderly shutdown. A UPS is required to maintain and provide continuous, conditioned power to the critical C-E equipment and to provide protection from power line transients. The UPS must have the following specific properties.

1. A UPS should serve the critical technical load. It should be solid state with batteries capable of supporting 125 percent of the critical technical load for a minimum of 15 minutes. The UPS is designed to protect equipment from disturbances of voltage and frequency inherent with conventional power distribution systems. The UPS must maintain output voltage and frequency regardless of the nature or severity of the incoming line fluctuations and/or changes in load.

2. The UPS should operate in conjunction with the existing power distribution system to provide quality power for critical technical loads. The system should consist of a solid-state inverter, a battery charger/rectifier, storage batteries, and a static transfer switch with a bypass switch.

3. During normal station operation, the UPS will be supplied with a.c. power by the primary power source; the UPS then changes a.c. power into storable d.c. electrical energy to be used as a short-term, no-break power supply for critical equipment. The UPS uses only a small amount of energy to maintain storage levels. The rest is reconverted into a.c. electrical energy. The UPS' a.c. power input and output are isolated from each other by the energy storage medium. A means should be provided to bypass the UPS completely in the event of failure or maintenance. (1)150 UPS electronic components should be in a room separate from machinery and batteries to prevent their vibration, pollution, overheating, and corrosion. See MIL-HDBK-411A for air-conditioning criteria.

   The four common types of installed UPS are:

   a. Flywheel--motor-generator
   b. Rotary
   c. Electronic
   d. Hybrid

policy / sop

4. The power sources and distribution system should be dependable, free from disturbances, and easily maintained. Efficient operation of the earth complex requires a dependable power system that minimizes the number and length of communication outages. Added to the primary objective of dependability are: (a) cost effectiveness to provide the best possible system for the least amount of money and (b) standardization to aid in cost effectiveness, maintainability, and ease of support. Additional information is available in MIL-HDBK 411A,AR 420-43, NAVFAC DM-4, NAVFAC DM12.1, AFM 88-15, and the National Electrical Code. (1) 30

5. A modern solid-state UPS is a reliable source of conditioned power. The UPS usually is provided with an electronically controlled static bypass switch when input and output frequencies are identical. The static switch permits automatic bypass if the UPS fails. Also, a manual bypass switch is often provided to permit maintenance on any part of the UPS system. (1) 153 Solid-state UPS have many advantages over mechanical rotary UPS. Bearing, vibration, and low efficiency problems are avoided, and single-point failures are minimized by selection and proper configuration of solid-state UPS. Reserve battery capacity of 15 minutes is normally enough for bringing the UPS online, at which time the auxiliary power plant should be providing the input power. (19) 17

   See Vol 2, SB2, for detailed information on UPS.

issues and assumptions

1. Selection of UPS

   Single UPS--The single, static UPS has the advantage of simplicity and low cost. The single UPS configuration consists of a rectifier, an inverter, associated controls, protective devices, and an energy storage battery. This system also includes a static bypass circuit that automatically transfers the critical load to the alternate power source without an interruption to the load. When an inverter output failure is sensed, the critical load is transferred to the bypass circuit in less than 5 milliseconds. The synchronous bypass adds about 20 percent to the cost and provides eight to ten times more reliability. UPS failure causes the static switch to transfer the load to the input source, keeping the load online. When selecting this configuration, two conditions must be considered for successful operation: (a) the transfer must be fast enough that the load will not be disconnected and (b) the frequencies and voltages of the primary power and the inverter output must be the same.

   Parallel redundant system--This system consists of at least two UPS operating in a load-sharing mode. The output of each is normally connected to the bus through a static interrupter for protection. If an internal fault occurs within an inverter of either system, the static interrupter isolates that inverter from the bus. In case of a bus fault, the interrupter operates in a current limiting mode until the output circuit breaker trips. Parallel UPS may be configured for various combinations of units operating in parallel, such as three units on-line with any two capable of serving the load. Parallel configuration is recommended when the frequency of the primary electric power supply must be converted to serve the critical load such as 50 to 60 hertz.

   "Cold" standby independent UPS--This configuration consists of two independent UPS with a common battery. One UPS is online and the other is in "cold" standby. Both UPS are equipped with static bypass circuits that, in the event of UPS failure, automatically transfer the critical load to the primary or auxiliary power source without interruption. The second UPS is then energized manually and placed in the bypass mode and the critical load is assumed by the transfer action of the static switch. The two UPS are not intended to operate in parallel and interlock circuits are provided on the UPS output.

issues and assumptions

2. Float battery systems versus solid-state UPS

The float battery system is the most economical and reliable method of providing continuous d.c. power to critical loads. Since this system is inherently very reliable and since future power sources (renewable energy) provide d.c. power, long-range communications plans call for increased use of d.c.-powered electronics. (19) 10

Floating battery power should be designed for optimal reliability and maximal independence of primary power abnormalities. The battery should be sized to furnish full power to the critical technical load for a period consistent with requirements and system design for auxiliary power capabilities. The battery system supporting solid-state UPS should be sized for 15 minutes in most cases. For 48-volt applications, if specific battery operation requirements are not available, the batteries should be sized for 4-hour operation at attended sites and a minimum of 8 hours' operation at unattended sites. A single float battery system should be designed for all float battery requirements in a common facility. A minimum of two rectifier chargers should be provided. The total number of rectifiers required will be determined by the number needed to supply the load and battery charging current, plus one or more for the maintenance space. When operating on commercial power, the rectifiers should be sized to provide a battery recharge-to-discharge time ratio of not more than 30 to 1. When static inverters are used, provisions should be made to transfer the load gradually from the battery to the primary or auxiliary power source. This provision, normally handled by the rectifier, will minimize transient conditions on the primary or auxiliary power source during the transfer period. (19) 22

activities

1. Doing prescribed maintenance and inspection (PMI) work.
2. Conducting operational checks and load tests.

personnel

1. One, though not located in room continuously.

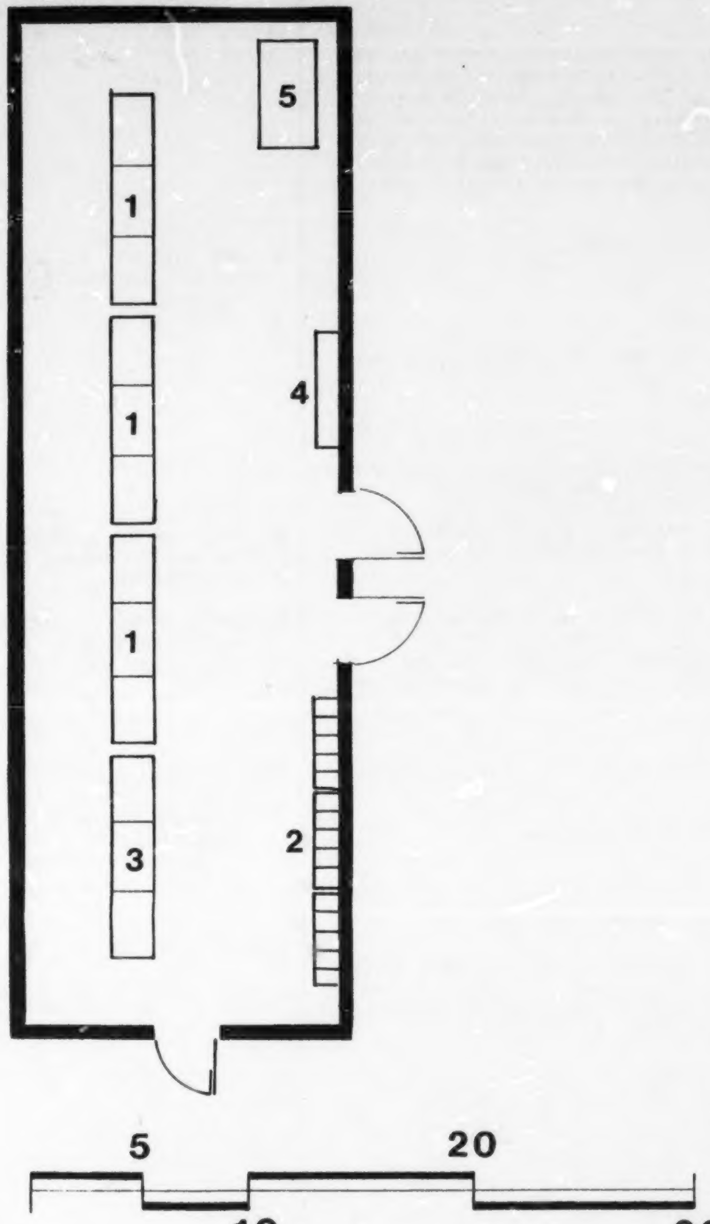
equipment *

1. Solid-state rectifier/charger.
2. Batteries.
3. Inverter, synchronizing equipment.
4. Static switches.
5. Rotary converter (if 60-hertz equipment is used in a 50-hertz host country.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for the operation and monitoring of UPS equipment; proper spacing between equipment for easy maintenance.	1. Space needs vary with the communication equipment design (i.e., power requirements), but an average is 400 to 500 square feet. Depending on UPS capacity, certain components are very large and heavy, so consideration must be given to installation and repair or replacement of those items. To accommodate this, knock-out panels may be required. Cable ducts should be located for easy access and drainage.	
2. Interior finishes suitable for durability, maintenance, and room function.	2. Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	2. See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation and attenuation for variable noise levels produced by electronic equipment.	3. Adjacent room walls should limit sound transmission to 40 decibels.	
4. Adequate lighting.	Provide 20-footcandle (ambient) fluorescent fixtures and 70 footcandles (task) for testing and inspection.	
5. Environmental control for proper operation of electronic equipment.	5. Regulate temperature at 50°F for heating. Cooling temperature must be less than 90°F for all solid-state UPS equipment.	5. See also Vol 2, SB2, Communication Station Buildings--Mechanical.
6. Electrical power.	6. Commercial electrical service used in the building will be site-specific. Availability depends on the host country if OCONUS. An outdoor transformer can be installed for UPS spaces in terms of the communication equipment and switchgear. Provide 120-volt receptacles as needed.	6. See also Vol 2, SB2, Communication Station Buildings--Electrical.
7. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	7. Interior enclosure walls--1-hour fire-rated construction. Interior doors--20-minute fire-rated doors. Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	7. See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



guidance

1. Location

The UPS and associated battery should be installed in separate rooms. Construction should be permanent type and the wall separating the UPS should be fire-rated (See Vol 2, SB3). Power continuity during emergency periods of power transfer is maintained by an energy storage battery. Reserve battery capacity of 15 minutes normally is enough for bringing the UPS online, during which time the auxiliary power should be providing the input power.

Structural--Minimum floor load is 250 pounds per square foot. A clear ceiling height of 10 feet should be provided.

Doors--All doors to the UPS room should be constructed of steel and should have a minimum dimension of 4.0 by 7.0 feet. Consider installing a louvered bottom door panel on the interior door(s).

5. Environmental control

Consider installing a solid-state UPS in an environmentally controlled room if adverse environmental conditions exist or if recommended by the UPS manufacturer.

guidance

Figure SC-2, A and B, show the preferred method of heating and ventilating UPS equipment areas, as well as providing the required ventilation system redundancy. The canopy hood, also called a "receiving hood," should be slightly larger than the equipment or exhaust grills in the cabinets and should extend fairly close to them. Direct connections should be avoided unless specifically recommended by the equipment manufacturer. Each exhaust fan should be sized to handle all the air exhausted through the cabinets plus 10 percent (room air) to insure good capture. (5) 3-3-13.

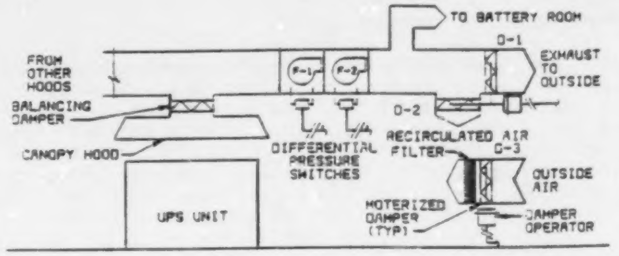

TO BATTERY ROOM
D-1
EXHAUST TO OUTSIDE
FROM OTHER HOODS
F-1
F-2
BALANCING DAMPER
D-2
CANOPY HOOD
DIFFERENTIAL PRESSURE SWITCHES
RECIRCULATED AIR FILTER
D-3
OUTSIDE AIR
UPS UNIT
MOTERIZED DAMPER (TYP)
DAMPER OPERATOR

FIGURE SC-2A. SERIES FAN ARRANGEMENT. (5) 3-3-14

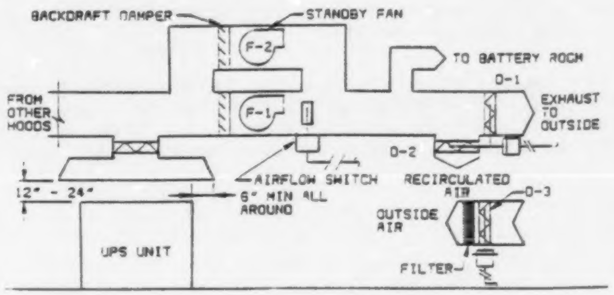
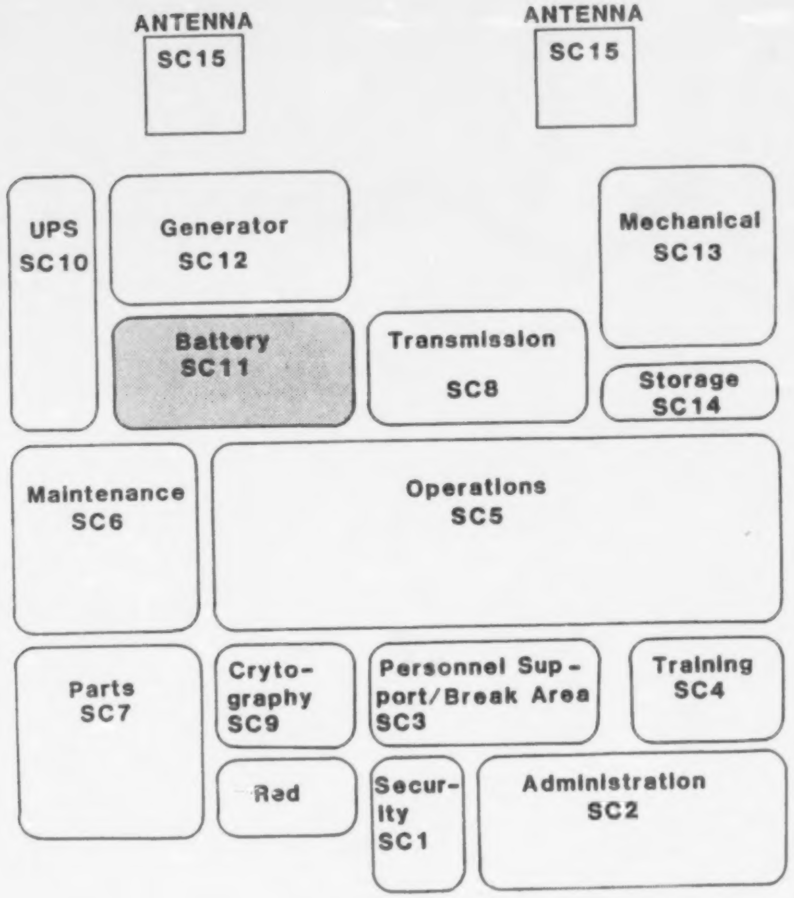

BACKDRAFT DAMPER
STANDBY FAN
F-2
TO BATTERY ROOM
D-1
FROM OTHER HOODS
F-1
EXHAUST TO OUTSIDE
D-2
AIRFLOW SWITCH
RECIRCULATED AIR
12" - 24"
6" MIN ALL AROUND
D-3
OUTSIDE AIR
UPS UNIT
FILTER

FIGURE SC-2B. PARALLEL FAN ARRANGEMENT. (5) 3-3-14

guidance

BATTERY SC11


ANTENNA
SC15
ANTENNA
SC15
UPS
SC10
Generator
SC12
Mechanical
SC13
Battery
SC11
Transmission
SC8
Storage
SC14
Maintenance
SC6
Operations
SC5
Parts
SC7
Cryto-graphy
SC9
Personnel Sup-port/Break Area
SC3
Training
SC4
Rad
Secur-ity
SC1
Administration
SC2

function

The battery room houses batteries that help comprise the backup power system (UPS), a system designed to provide continuous power to the critical load without delay.

policy/sop

1. Battery bank. This should be used as a stored energy source for the UPS. The battery's ampere-hour rating should be high enough to support the inverter for the protection time specified with the mover for operating at rated load. The battery should meet input voltage requirements of the inverter section.

2. Construction. Batteries should be the sealed type, assembled in heat-resistant, shock-absorbing, clear plastic containers with covers cemented in place to form a permanent leak-proof seal. Covers should be fitted with explosion-resistant vent caps. Cell post and cover should be sealed by lead-alloy steel nuts. Cell terminal posts should be equipped with connector bolts that have acid-resistant nuts. Enough sediment space should be provided so that the battery will not have to be cleaned during its normal life. Electrolyte level lines shall be marked on all four sides of the container.

3. Ground protection. The battery should have a high-resistance ground and a ground detection alarm for maximum safety; this will be an integral part of the UPS.

4. UPS batteries should be isolated from machinery in a properly designed battery room to prevent their damage from vibration, pollution, overheating, or explosion.

5. Battery Rack: At all sites, the seismic category should be considered. For example, safety restraint rails are recommended to hold batteries securely in place. A minimum of category I earthquake proof racks are recommended for use at all locations.

issues and assumptions

1. Batteries versus generators for "backup" power

The use of batteries as the only backup power is impractical at high-power communications facilities. Some use can be made of batteries for backup at receiving facilities and possibly for low-power (up to 1 kilowatt) transmitter radio facilities, but even this is questionable. Normally, there will be engine-driven generators at the facility to pick up the load within approximately 1 minute of the power failure. Maintaining large banks of batteries for use during an occasional power outage may not be cost-effective. (87) Vol 2, 86

activities

1. Inspecting battery system quarterly.

personnel

1. None assigned fulltime.

equipment *

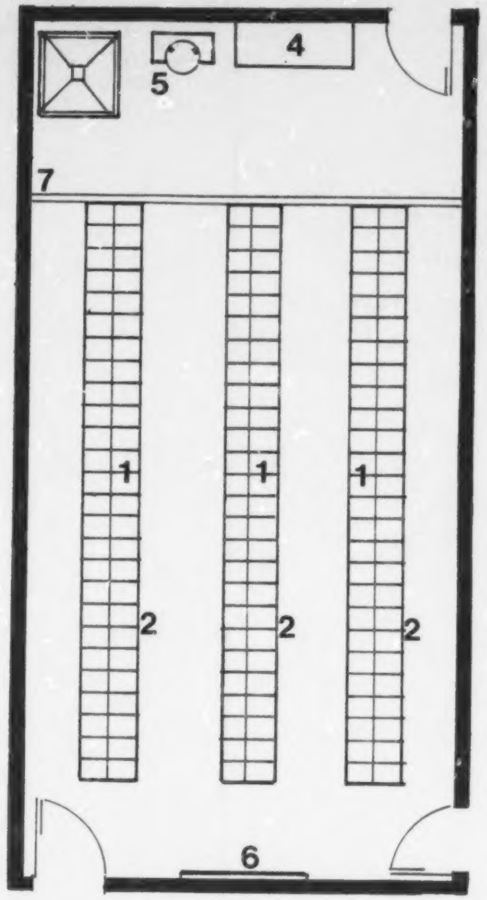
1. Lead acid batteries.
2. Battery racks.
3. Rectifier chargers.
4. Counter workbench for battery maintenance.
5. Emergency eyewash fountain and shower.
6. Safety board, 96 by 48 inches, wall-mounted.
7. Four cans of soda and four jars of distilled water.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for batteries and rectifier chargers to contain the proper safety equipment associated with the battery function.	**1.** Approximately 900 square feet are needed to provide space for battery racks, emergency eyewash, and shower equipment.	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Concrete, hardened and sealed. The battery room requires treatment with an acid-resistant floor hardener. Base--Not applicable. Walls--Paint with tile wainscot of 48 inches. Ceiling--Exposed and painted.	**2.** See also Vol 2--"Site and Building Information," SB2, Interior Construction and Finishes.
3. Acoustical isolation for adjacent mechanical equipment rooms that produce variable noise levels.	**3.** Adjacent room walls should limit sound transmission to 40 decibels.	
4. Acid removal.	**4.** A special drain system is needed to accommodate acid spills. Provide a curb to contain acid and keep it from entering the shower drainage area.	**4.** The battery room contains highly explosive fluids and fumes. It is important that item specifications be explosion-proof and meet Occupational Safety and Health Administration (OSHA) regulations. Recommend a pumpable acid holding tank that will hold up to 50% of acid volume.
5. Safety board.	**5.** Use 96- by 48-inch mounted board for assigned safety gear and a large enough floor area to store four cans of soda and four jars of distilled water.	
6. Separate exhaust ventilation system to outside.	**6.** An interlock must be provided to deenergize charging circuits if ventilation fails or shuts down. See SB2, Special Mechanical Systems, for ventilation rates.	
7. Adequate lighting.	**7.** Use 60-footcandle fluorescent lighting in corrosion-proof and explosion proof fixtures.	
8. Thermal comfort.	**8.** Maintain temperature at 60°F for heating. 104°F is the maximum allowable temperature.	**8.** See also Vol 2, SB2, Communication Station Buildings, Mechanical.
9. Electrical power.	**9.** Provide 120/208 electrical service. All 120-volt fixtures and switches are to be Class II. Locate one receptacle for every 10 linear feet of wall. Metal battery racks will be grounded to the earth ground system. (Explosion-proof electrical receptacles and fixture explosion venting are not required, but are recommended.)	**9.** See also Vol 2, SB2, Communication Station Buildings, Electrical. Air Force recommends no receptacles in Battery and will not usually use electrical equipment in room.

requirements	criteria	commentary
10. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**10.** Interior enclosure walls--1-hour fire-rated construction Interior doors--20-minute fire-rated doors Interior finish--Class A or B only Automatic fire suppression--Water sprinklers Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility Explosion-proof electrical receptacles and fixture explosion venting.	**10.** See Standardized Modules--Building Design Principles and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance


4
5
7
1
1
1
2
2
2
6

3. Rectifier chargers may not be physically co-located with the batteries.

guidance

1. Location

Battery rooms, consisting of cells mounted on manufacturer-supplied battery racks, are normally adjacent to the UPS equipment room. The battery room should be windowless, reasonably well insulated against heat loss and gain, and located to minimize solar gain. Frequency conversion equipment should be as close as possible to the equipment it serves. Motor generators should be located in a separate room to reduce noise levels and heat gains in operating spaces. Static converters can be located in the equipment space or operating space because they produce minimal heat and noise. (92) 12.1-12

Spatial needs

The 48-volt d.c. battery set consists of 24 cells with interconnections, mounted in a two-tier seismic-resistant rack. (Figure SC-3.)

A suitable galvanized steel rack should be furnished. Lead-plated copper interrack connectors and cell numbers should be provided. Plastic covers should be provided to insulate rails and cells. Racks should be painted with two coats of acid-resistant paint.

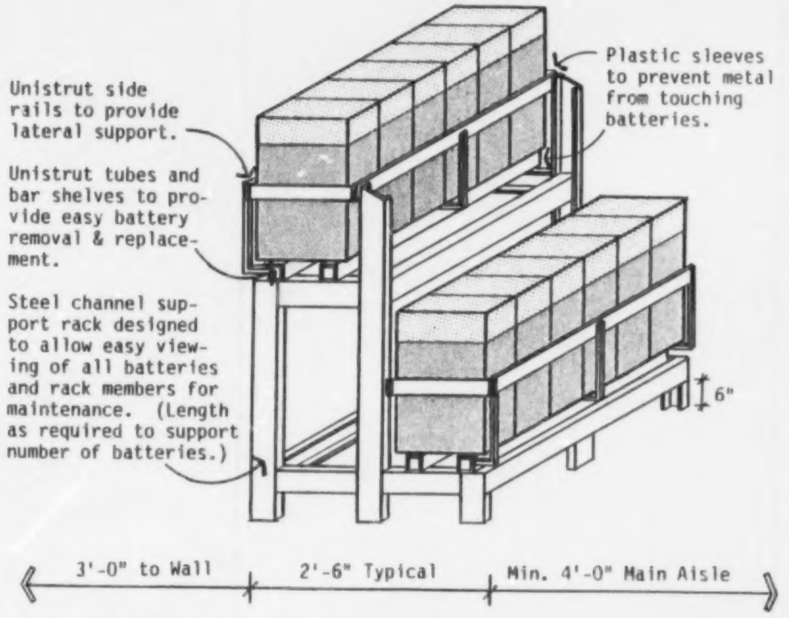

Unistrut side rails to provide lateral support.
Unistrut tubes and bar shelves to provide easy battery removal & replacement.
Steel channel support rack designed to allow easy viewing of all batteries and rack members for maintenance. (Length as required to support number of batteries.)
Plastic sleeves to prevent metal from touching batteries.
6"
3'-0" to Wall
2'-6" Typical
Min. 4'-0" Main Aisle

FIGURE SC-3. TYPICAL BATTERY STORAGE RACK

guidance

The 48-volt d.c. power can consist of two, three, or four rectifiers with storage batteries sized properly to meet each site's power requirements. The rectifiers can be operated in a parallel/redundant mode, which extends the equipment life and provides uninterrupted service should one cell fail. Rectifiers should have a "current walk-in" feature for a smooth increase in current with initial power-up to protect the load and prevent accidental circuit breaker tripping. Rectifiers also should have a current limit control that can be adjusted from 90 to 125 percent to limit the output current. A voltmeter and an ammeter can indicate rectifier operation and front panel alarm lights are available for external monitoring. Battery plant capacity should be sized to support the total load. (88)G-1

2. Durable surfaces

All floors, walls, and ceilings should be made of acid-resistant materials. Exposed concrete is recommended for the floor.

All doors to the battery room should be constructed of steel and should have a minimum dimension of 4.0 by 7.0 feet (1.22 by 2.14 meters). Consider installing a louvered bottom panel on the interior door(s).

Exhaust fans in the battery room should be covered with security bars and be explosion-proof. See SB7 in Vol. 2.

The battery room floor design load should be 250 pounds per square foot (1220 kilograms per square meter).

4. Acid Removal

All required actions must be taken to meet host country laws and regulations against the water and air pollution. An acid-resistant drain line should be installed between the battery room floor drain and the "pumpable" holding tank for chemical waste. Connections to sewage lines is unacceptable. Vent lines also should be acid-resistant.

6. Exhaust ventilation

The battery room is to be supplied with its own ventilation intake and exhaust ports to outside air. (40) 6-8

The central ventilation system supporting air to and exhausting air from the building can be used to supply air to the battery room for exhausting to the outside. (40) 6-8

Battery rooms shall be ventilated with nonsparking, explosion-proof, continuously operating exhaust fans to maintain a stable room pressure that is lower than that in adjoining rooms to prevent the outflow of contaminated air to other rooms. Required outdoor air ventilation rates for batteries and equipment shall be obtained from the manufacturer and shall be used in designing the environmental control system.

guidance

The battery room is normally ventilated by wall fans or power roof ventilators. Fans are sized so that either is adequate to limit hydrogen gas buildup to 2 percent. Both fans should have manual starters. If wall-mounted, they should be high enough to avoid hydrogen buildup near the ceiling. Backup electrical unit heaters sized to maintain a minimum temperature of 60°F (15°C) should be provided for times when waste heat is not enough to maintain the battery room temperature at its winter design level. Heaters should be on the utility or normal power circuit.

7. Lighting design

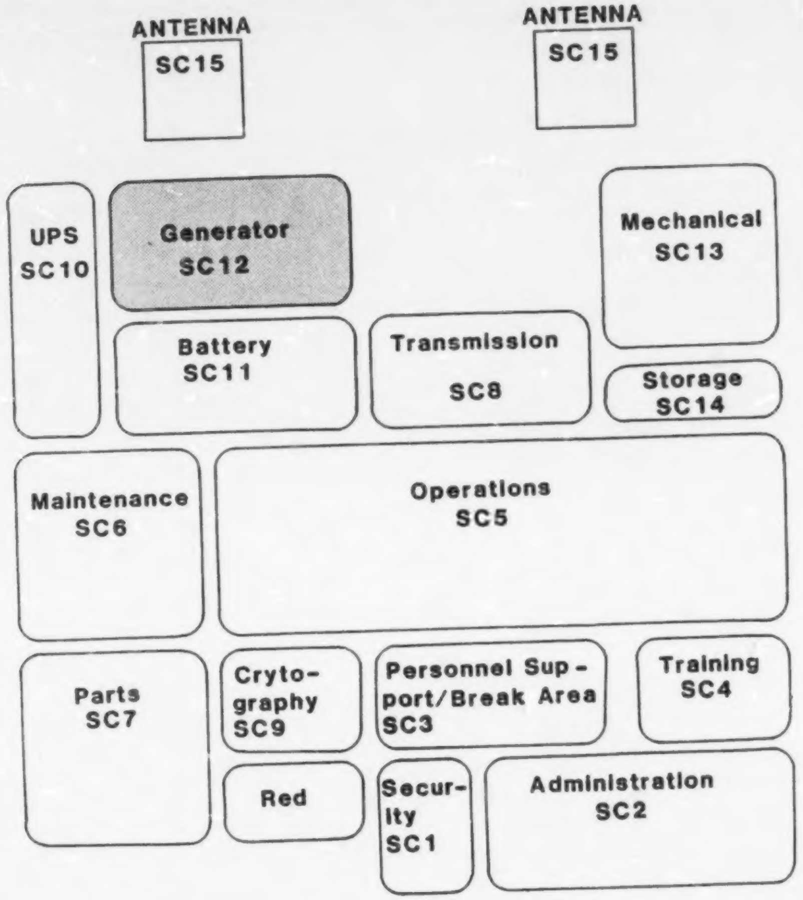
Explosion-proof fluorescent lighting fixtures should be installed in the battery room. Lighting levels in the battery room should be no less than 30 footcandles, 25 measured 30 inches from the floor. The light switch should be located outside of the battery room on the wall next to the door.

10. Life safety

A combination emergency deluge shower and eyewash fountain should be installed in the battery room.

Battery Rack: At all sites, the seismic category should be considered. For example, safety restraint rails are recommended to hold batteries securely in place. A minimum of category I earthquake proof racks are recommended for use at all locations.

GENERATOR SC12



function

Facility generators maintain power to all communication systems when the commercial power fails.

policy/sop

1. Facilities usually will have three generators as a backup power source in the event of commercial power failure:

   - One generator will be online, set for automatic startup
   - Another will be backup to the first, in case of failure
   - A third generator will be considered "in maintenance" condition to be available if the backup generator fails.

   (See MIL-HDBK 411A for specific policies on the various generator classes.)

2. Primary power requirements for a communications facility are determined by the system configuration and include equipment loads (technical power), utility and domestic loads, and provisions for future expansion. The architectural engineering agency is responsible for designing the site primary power system and its distribution. One of the most economical, convenient sources of auxiliary power is the diesel-engine generator. However, an engine-driven generator requires time to start and warm up, causing a delay before taking the load after a power failure. The recommended practice is to use storage batteries to provide power instantly and economically. They are kept fully charged by the primary power source during normal operation and, when failure occurs, they assume the load instantly without interruption to service. Batteries lack the capacity to supply power for a long period of time, so it is necessary to have an auxiliary generator available. (70) 15-11

3. On-station prime power plants are considered only when the local power is either extremely unreliable or prohibitively expensive, when no power is available, or when self-sufficiency is required for survival and reliability in a wartime environment. On-station prime power plants normally use multiple sets of DOD standard family, diesel-engine generator sets for the power source. Other sources (such as wind turbines, thermoelectric generators, fuel cells, gas-turbine generators, steam-turbine generators, and nonstandard diesel-engine generators) can also be used and should be considered when requirements for a wartime DCS dictate. An onstation prime power plant will use a minimum of three engine generator sets with one set online to carry the station load, one set as a standby, and one set as a maintenance spare. A more reliable configuration is to use four or five generator sets with two online in a load-sharing mode, one as a cold standby unit and one or two as maintenance spares. When the station's standby power requirements exceed 70

policy / sop

percent of the total power requirements and the standby power is redundant, a study should be done in accordance with DOD 4270.1-M to determine if it would be more economical to provide a total energy system that produces both electrical and steam power to be used as needed. (1) 31

4. Site personnel efficiency will be improved if it is possible to locate noisy mechanical equipment, like some diesel generators, away in housing separate from working and living areas or if some other type of noise control is provided. Also, care must be taken to insure that fresh air intakes do not catch fumes or odors from sources such as diesel generators. (2) 5-25

5. All onsite power sources (generators) and substations should be located at a point in the station boundary for which security is adequate. Additional guidelines for locating power sources and substations are: (1) 32

   a. The primary onsite power source should be located far enough from the station work areas to insure acceptable noise levels as outlined by the acoustical noise requirements of MIL-STD-1472.

   b. The primary substation should be located for convenient delivery of power from an off-station source and for easy distribution of the power to onsite facilities as required.

   c. Distribution substations should be located as close as possible to the parts of the operating building they serve.

6. Total fuel storage tank capacity should be determined by local replenishment opportunities, but should hold at least a 30-day supply for primary Class A on-station generators per MIL HDBK 411A. Class C generators require a 7-day minimum supply and Class B generators require a 15-day minimum stored fuel supply. The storage tank(s) should be constructed of fiberglass and when practical, installed underground on an incline to prevent sediment accumulation. Provisions should be made for easy filling and removal of water and other sediment. (19) 13.

issues and assumptions

1. Commercial power versus generators

The mission of DCS communication facilities is to provide reliable communications 24 hours per day. Ideally, the power source for the mission equipment should be reliable, well regulated, easily maintained, and free of transients and disturbances. In actual practice, these desirable characteristics are seldom achieved on a long-term basis. Other factors to be considered in the choice of a facility power supply are:

   a. Providing the best possible system for the least amount of money (cost effectiveness).

   b. Standardizing for better cost effectiveness.

   c. Providing easy support (maintainability). (87) Vol 2, 62

Normally, a DCS communications facility will operate from commercial power using local generators for backup. In some areas of the world, however, commercial power may not be available or if it is, it may be so unreliable as to be unusable for the technical load. Such supplies may be satisfactory for the nontechnical load (area lighting, housing, etc.). In such cases, the primary power source should consist of generators located on the facility site. (87) Vol 2, 83

2. Comparison of engine generators

The selection of an engine generator to supply an independent power source (primary and/or standby) depends on several factors. The choice is usually between a diesel and a gasoline engine. Each has properties that determine its suitability for a particular application.

The diesel engine is suitable for either continuous or part-time service. Initial cost is slightly higher than that of a comparable gasoline engine; for certain applications, however, this disadvantage is more than offset by advantages. The diesel engine is extremely rugged, uses less and lower cost fuel, has a long life expectancy, and offers maximal reliability. Reasons for these advantages include (a) diesel fuel has a higher energy content than gasoline or liquid petroleum, (b) diesel engine operating speed is approximately half that of the gasoline engine, and (c) the diesel engine does not require an electrical ignition system. The last two factors account for lower maintenance and overhaul costs for the diesel engine. Engine starting time is comparable for diesel and gasoline engines.

Gasoline engines can be used for continuous power, but are better suited for standby use. As mentioned previously, the gasoline engine has a lower initial cost, but also a shorter life expectancy. It has a higher operating speed, which wears out the engine more rapidly. It uses more and higher operating speeds, which also wear the engine out more rapidly. It uses more and higher cost fuel and is not as reliable as a diesel engine. One reason for poor reliability is that a gasoline engine uses an electrical ignition system which is subject to failure due to dampness, age, and carbon buildup. (70) 14-3

issues and assumptions

3. Level of maintenance performed

If depot level maintenance is required and authorized, an open area, benches, and special tools (torque wrenches) also are required in the generator room. This is especially true at Navy installations, which require more extensive repair onsite.

4. Above-ground versus below-ground oil storage tank

To insure protection from hostile attack, below-ground tanks provide better security for the standby power system; however, above-ground tanks are cleaned, repaired, and maintained more efficiently, effectively, and economically.

5. Sizing generator fuel tanks

Engine generator size depends on the station's power requirements. The fuel tank capacity for these units depends on the site's accessibility and the size of the engine generators. It should not be necessary to refill fuel tanks more than once a month. If inclement weather or undue hardship dictates a longer period of time between refuelings, a larger tank is recommended. The approximate rate of fuel consumption of a diesel-driven generator, in gallons per hour, can be calculated by multiplying the output in kilowatts by 0.136; this calculation will be helpful in determining the size of tank needed. (70) 14-2

activities

1. Starting the on-line generators after commercial power failure.
2. Repairing and maintaining generators.

personnel

1. Two personnel, though not in room continuously.

equipment **

1. One "set" of generators.* (Usually Class C.)
2. Batteries for start-up.
3. Fuel tank with dispensing pump. (Tank capacity varies with size of generators and reliability level of primary commercial power.)

   See MIL-HDBK 411 for the specific capacity in relationship to a class of generators.
4. Alarm panel.
5. Automatic transfer switches.

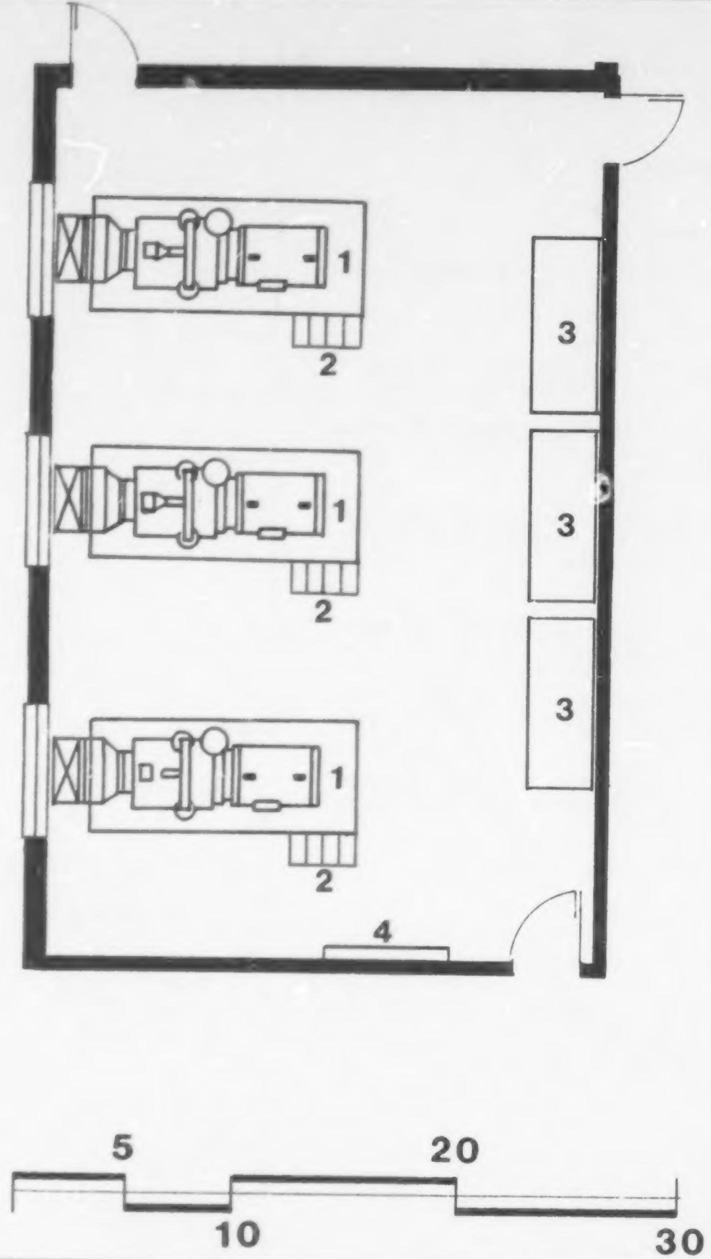
---

*The number and size of generators will vary among facilities depending on the voltage required to maintain the mission.

** see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for the installation, removal, and repair of standby generators.	**1.** Space needs vary with power requirements (see guidance drawing). Allow approximately 800 square feet for three generators.	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustic isolation for variable noise levels produced by mechanical equipment.	**3.** Adjacent room walls should limit sound transmission to 40 decibels.	
4. Generator operation indicator and alarms.	**4.** An alarm and operation indicator panel will be located at the control console area of the operations space.	
5. Emergency lighting.	**5.** Emergency lighting should be bright enough to allow switch gear operation, instruction reading, and other mission-essential activities.	
6. Environmental control to provide generators' constant supply of make-up air for combustion and cooling.	**6.** Provide automatically adjusted louver units sized for capacity of generator selected. Exhaust stacks must be caged to prevent bird/animal entry.	
7. Vibration control.	**7.** The generators must be placed on a concrete pad physically isolated from the main floor.	
8. Design that allows complete removal and exchange of generator units.	**8.** Air intake/exhaust units should be located and sized to become a "knock-out" panel for removing a complete generator.	
9. Adequate lighting.	**9.** Use 40 footcandles (ambient). "Slow start" fixtures such as mercury vapor should not be used, nor should fluorescent fixtures.	
10. Thermal comfort.	**10.** Regulate temperature at 50°F for heating.	**10.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
11. Electrical power.	**11.** Provide 120/208 electrical service. Install 120-volt outlets; at least two duplex receptacles are required at workbench areas and at the appropriate height. Use 240-volt receptacles when required. Provide host nation standard outlets if applicable.	**11.** See also Vol 2, SB2, Communication Station Buildings--Electrical.

guidance



guidance

1. Location

If a standby generator is to operate continuously for instantaneous commercial power backup, the generator room should be located away from all normal operational spaces to isolate the noise.

Clearances--All ducts and other systems installed in the facility as part of the finished structure should be arranged to maintain a 10-foot unobstructed clearance from the floor to the ceiling.

Structural--Isolate the foundations of each generator to prevent transfer of engine vibrations to the building. Floor loading should be designed to accommodate a steady load of the heaviest auxiliary diesel engine generator designed/selected by the contractor. Pad dimensions may exceed the engine dimensions by 25 to 30 percent.

Doors--All single doors should be constructed of steel and should have a minimum dimension of 4.0 by 7.0 feet. The exterior equipment door for the generator room should be double-wing type with minimum dimensions of 6.0 by 7.0 feet. This door should be equipped with a drop-in horizontal bar to secure it from the inside.

Storage tank--When required, provide an underground fuel oil storage tank adjacent to the power/mechanical room. Also provide fuel oil supply and return lines, fill pipe, oil level gage, and alarm conduits. This tank must be equipped with a float switch to activate an alarm indicating a low fuel oil condition.

A single storage tank should be provided for a minimum fuel supply for both the heating boiler and diesel engine generators. MIL HDMB 411A requires Class C generators to reserve a 7-day supply, Class B generators should reserve a 15-day supply, and Class A generators should reserve a 30-day supply. A fiberglass underground tank should be used. A day tank should be provided in the building to supply fuel to both the heating boiler and diesel engine generators. (See also Vol. 2, SB1, Site Planning and Development).

Provide floor trenches in the power/mechanical room for supply and return fuel lines from the exterior fuel oil storage tank and for cable runs from the generator to the transfer switch and main distribution panel. Floor trenches should have 0.25-inch-thick steel plate covers.

guidance

4. Alarm system

Provide a wall-mounted alarm terminal panel in the generator room. The following alarms will be terminated there:

- Generator status
- Commercial power status
- Low fuel oil level (48-hour supply)
- High (80°F) or low (55°F) temperature status in communication equipment and power mechanical room
- Generator start failure.

The termination board or its associated housing should have all alarm terminations identified clearly with permanent marking or labels for future extensions of these connections to a control and fault alarm system. The alarm sensors should incorporate only dry contacts (no voltages) and should use two conductor shielded cables in the circuit runs or in conduit to the consolidated terminal panel noted above.

Provide adequate grounding cable from the building ring ground system, when applicable, to the diesel generator set metal frame and to the underground fuel oil storage tank. See Vol 2, SB4.

6. Environmental control

Generator exhausts should be located such that fumes will not be sucked into other HVAC air intakes. Emergency generators can be located inside the operations building if they are isolated properly from the rest of the structure in terms of fire protection, sound attenuation, and vibration control. (92) 12.1-12

Louvers and Openings

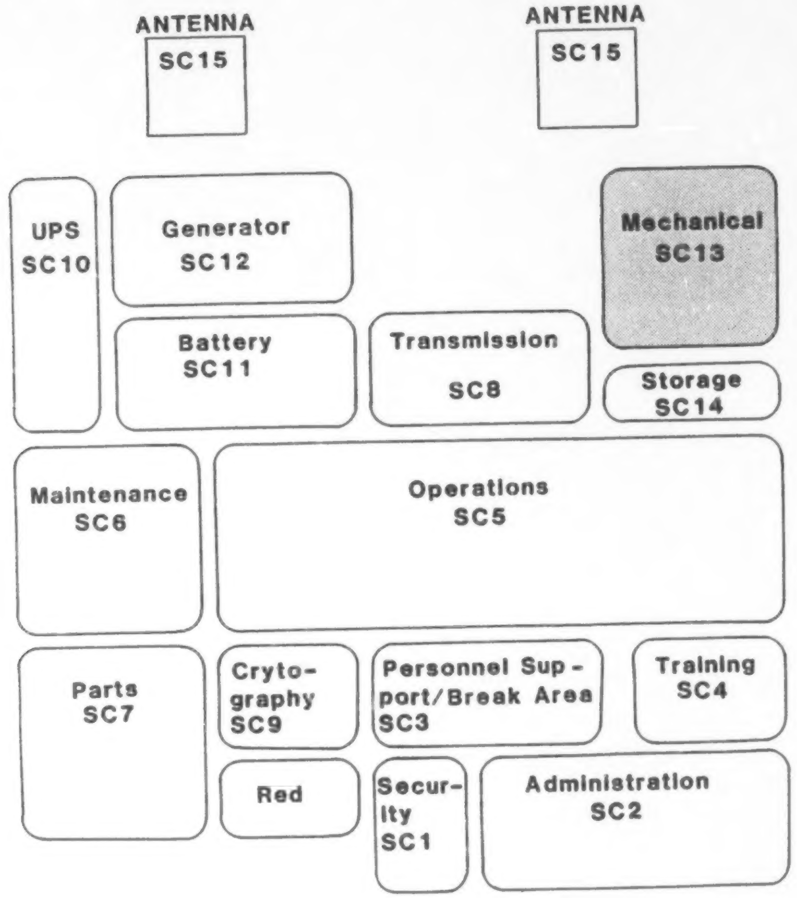
Provide motorized air damper openings in the generator room walls to accommodate diesel engine combustion air requirements. Dampers should automatically activate when generator starts.

Provide security bars on all openings subject to physical intrusion (greater than 7.6 feet in perimeter) such as air intake and exhaust louvers. Their attachment to the structure must be nonremovable from the exterior.

See Vol 2, SB7, for security guidance.

guidance

MECHANICAL SC13


ANTENNA
SC15
ANTENNA
SC15
UPS
SC10
Generator
SC12
Mechanical
SC13
Battery
SC11
Transmission
SC8
Storage
SC14
Maintenance
SC6
Operations
SC5
Parts
SC7
Cryto-
graphy
SC9
Personnel Sup-
port/Break Area
SC3
Training
SC4
Red
Secur-
ity
SC1
Administration
SC2

function

This module provides space for equipment to supply all the heating, ventilating, and air-conditioning (HVAC) and water requirements for the entire facility. It must also be flexible and spacious enough to accommodate alternative energy sources.

policy/sop

1. It is desirable to provide a separate room for mechanical equipment such as heat exchangers, air-conditioners, and waveguide dehydrators-pressurizers. Heat exchangers must have air intake and exhaust ducts to the outside of the building. The size of these ducts dictates that heat exchangers must be located close to the wall. It must not be overlooked that some types of heat exchangers may require rear access for maintenance. Location of the dehydrating-pressurizing equipment is not critical. However, ease of access for maintenance is desirable and the pressure gages should be readily visible to the maintenance personnel. The air-conditioning equipment location will depend on the specific type provided and whether or not intake and outside exhaust are required. (2) 5-24

issues and assumptions

1. Calculation of space requirements

   a. Heating for each area of the facility is commonly provided by an oil-fired hot-water boiler located in the mechanical equipment room. During the heating season, hot water is supplied from the boiler to the various heating, air-conditioning, and domestic hot-water systems. In the summer, domestic hot water is provided by a small oil-fired hot-water heater and the boiler is turned off. This arrangement will add to boiler efficiency and energy conservation.

   b. Provisions will be made in the mechanical equipment rooms to allow for removal of tubes from boilers and chillers as well as the removal of coils and filters from air handling units for maintenance and replacement. All equipment will be located to allow easy access for maintenance and servicing.

   c. Usage will be 24 hours per day, 7 days per week. No special provisions for peak usage are required.

activities

1. Maintaining, controlling, and inspecting mechanical equipment.

personnel

equipment *

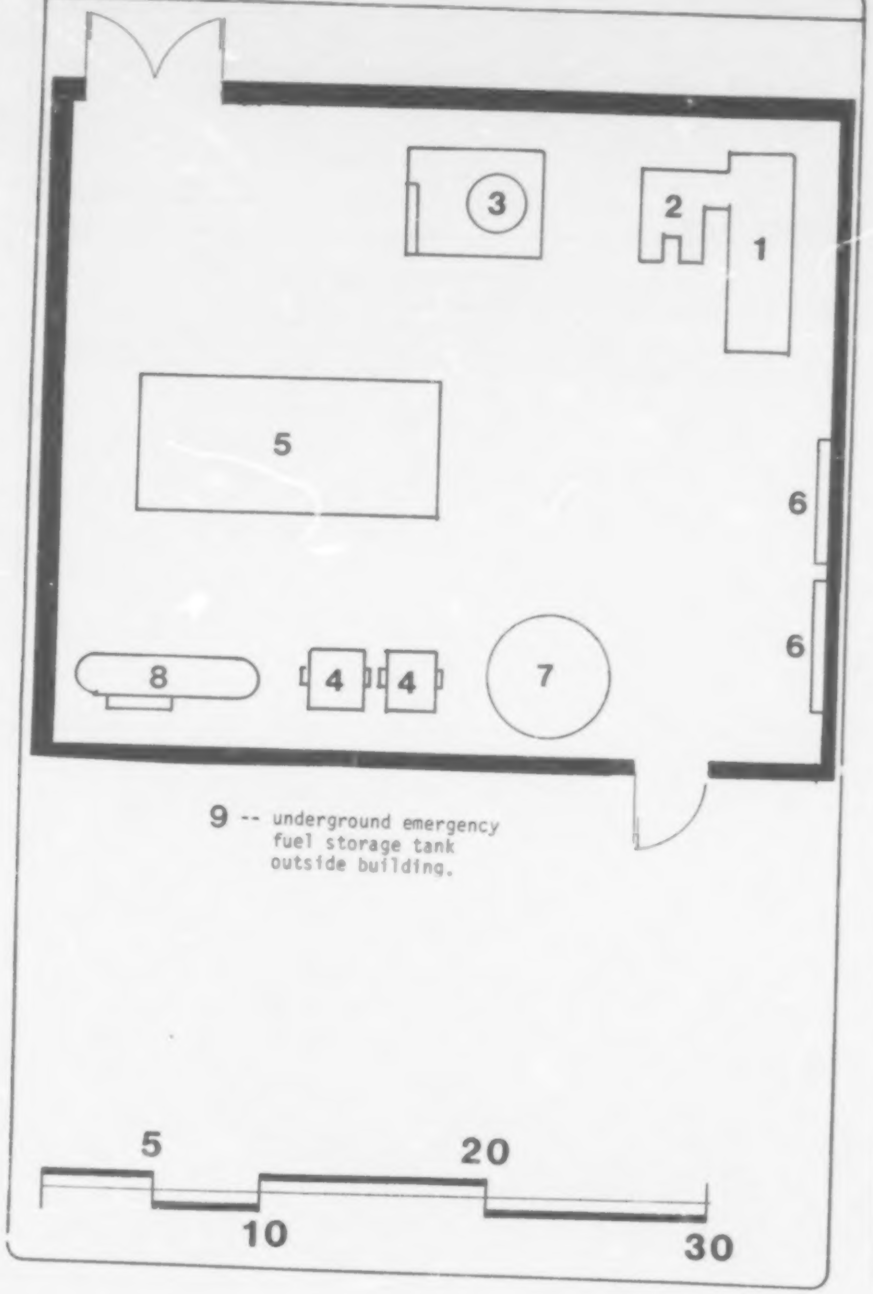
1. Chiller.
2. Condenser.
3. Compressor.
4. Water pumps.
5. Boiler.
6. Electrical switchboard.
7. Emergency water supply tank.
8. Day fuel tank.
9. Emergency fuel storage tank. (Underground--see Vol 2, SB8.)

Note: Alternative energy sources may vary and alter equipment needs. See Vol 2, SB6--AES, for information.

*see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate the mechanical equipment requirements associated with the facility's environmental maintenance.	**1.** The ratio of mechanical equipment space to the total facility interior floor space varies from 7 percent for small facilities to about 4 percent for large facilities. (See "Issues" box.)	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation for variable noise levels produced by mechanical equipment.	**3.** Adjacent room walls should limit sound transmission to 40 decibels.	
4. Information display.	**4.** The operating instructions, preventive maintenance schedule, wiring and control diagrams, and detailed control sequence should be framed under glass or plastic and posted for easy reference.	
5. Water supply and sanitary sewer.	**5.** The water supply and sanitary sewer for this facility will be connected to the existing post systems or as prescribed for foreign locations. Provide an emergency water supply tank of 20-gallon per capita capacity for 7 days. Water must be refreshed periodically. See Vol 2, SB8, Survivability Protection.	
6. Adequate lighting.	**6.** Provide 40-footcandle fluorescent fixtures (ambient).	
7. Thermal comfort.	**7.** 50 to 68°F range (winter heating), except for batteries, which must be kept at 60 to 68°F.	**7.** See also Vol 2, SB2--Communication Station Buildings--Mechanical.
8. Electrical power.	**8.** Commercial electrical service used in the building will be site-specific. Availability depends on the host country if OCONUS. An outdoor transformer can be installed for the mechanical space in terms of general building power. Install 120-volt receptacles as needed. Electrical power must fall within the 10,000- to 500,000-watt range. Frequency levels should be at 50 to 60 hertz ± 5 percent.	**8.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
9. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**9.** Interior enclosure walls--1-hour fire-rated construction. Interior doors--20-minute fire-rated. Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**9.** See Standardized Modules--Building Design Principles, Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



9 -- underground emergency fuel storage tank outside building.

guidance

1. Storage tank

A single storage tank should be provided for a minimum 15-day supply for both the heating boiler and diesel engine generators. A fiberglass underground tank should be used. A day tank should be provided in the building to supply fuel to both the heating boiler and diesel engine generators. This tank must be equipped with a float switch to activate an alarm indicating a low fuel oil condition.

Doors--The exterior equipment doors should be steel, double swing type with steel frame. The inner opening should be at minimum 6 feet wide by 7 feet high. The equipment door should be equipped with interior locking panic hardware.

Both the exterior personnel and equipment door hinges must be welded to prevent removal of hinge pins if pivots and pins are on the outside.

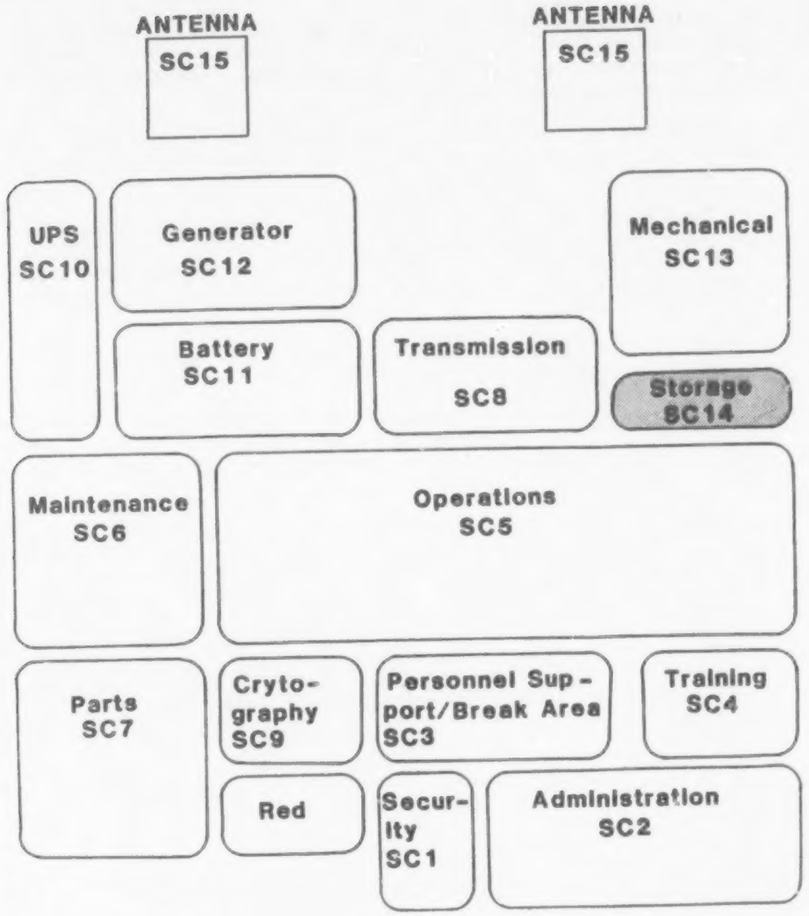
Provide security bars on all openings greater than 7.6 feet at the perimeter and subject to physical intrusion (for example, air intake and exhaust louvers). Their attachment to the structure must be nonremovable from the exterior. See Vol 2, SB7, for additional security guidance.

Structural--The minimum floor design load is 150 pounds per square foot. A clear ceiling height of 10 feet should be provided.

Mechanical equipment should be isolated to minimize vibrations. This can be done by mechanically isolating each individual system on concrete pads separate from the mechanical room floor.

Heat exchangers must be provided with air intake and exhaust ducts to the outside of the building. The size of these ducts means the heat exchangers must be located close to the wall. However, some types of heat exchangers require rear access for maintenance. Location of dehydration pressurization equipment is not critical, but ease of access for maintenance is desirable. Pressure gages should be readily visible to maintenance personnel. Location of the air-conditioning equipment depends on the specific type provided and whether intake and exhaust to the building's outside are required. (2) 5-25

STORAGE SC 14


ANTENNA
SC15
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UPS
SC10
Generator
SC12
Mechanical
SC13
Battery
SC11
Transmission
SC8
Storage
SC14
Maintenance
SC6
Operations
SC5
Parts
SC7
Cryto-graphy
SC9
Personnel Sup-port/Break Area
SC3
Training
SC4
Red
Secur-ity
SC1
Administration
SC2

function

This area is for the temporary placement of miscellaneous items and nontechnical equipment.

policy/sop

1. All services have physical fitness requirements that must be met. For remote DCS facilities that have no installation services available, it is recommended that exercise equipment be made available. The exacting, sometimes intense, activities of maintaining and controlling the DCS require periodic breaks for physical exercises.

issues and assumptions

1. Storage for exercise equipment

The exercise equipment should not conflict with the function of other personnel-oriented rooms. A general purpose storage room is suitable since the equipment is unofficial.

activities

1. Shelving of miscellaneous sized items.
2. Individual exercise.

personnel

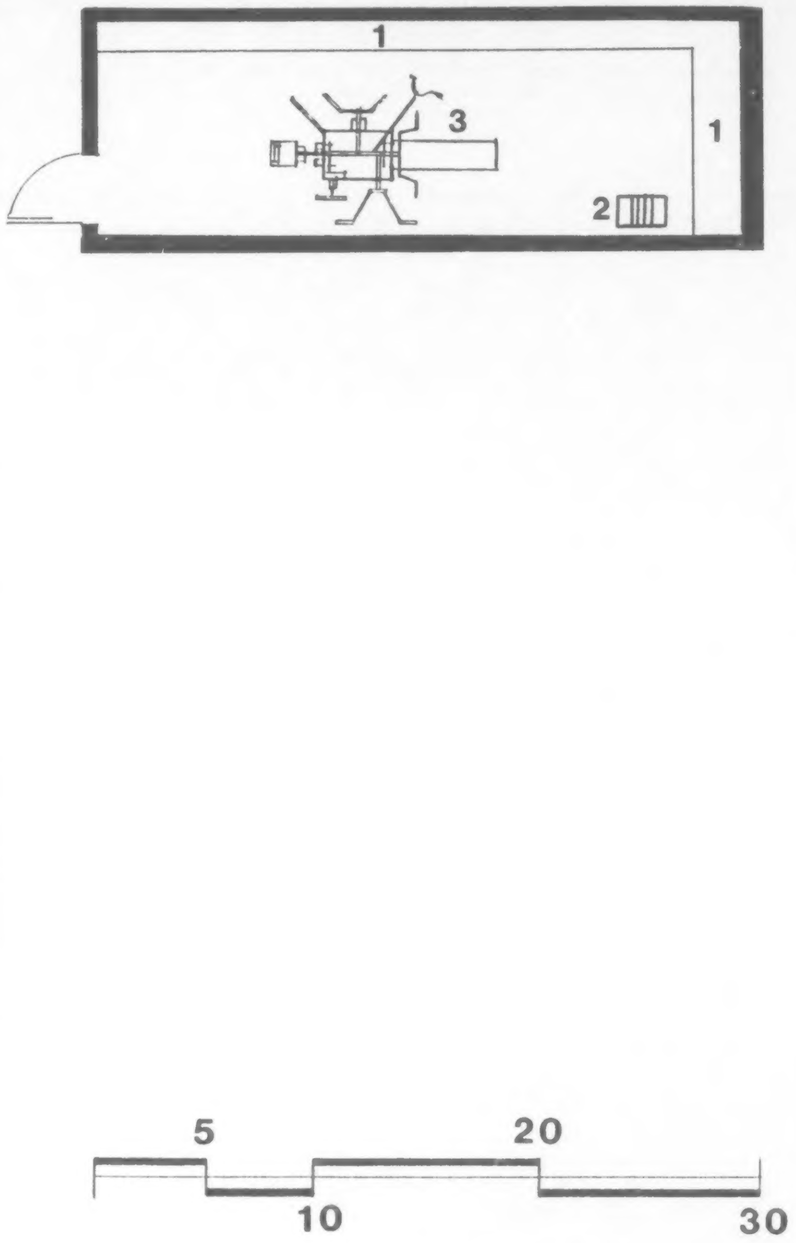
equipment *

1. Shelving 18 inches deep.
2. Small step ladder.
3. Exercycle, universal gym, and/or loose weights.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate two or three persons exercising, plus space to move about for shelving items.	**1.** Allow approximately 250 square feet to accommodate the exercise equipment plus 60 linear feet of shelf space.	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation and attenuation for a nondisruptive environment.	**3.** Adjacent room walls should limit sound transmission to 40 decibels.	
4. Adequate lighting.	**4.** Use 30-footcandle (ambient) fluorescent fixtures.	
5. Thermal comfort.	**5.** Regulate temperature at 68°F (heating), 78°F (cooling). Provide 10 cubic feet per minute per person outside air ventilation rate with on-off switching.	**5.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
6. Electrical power.	**6.** Install 120/208 electrical service. Provide 120-volt outlets--one receptacle for every 10 linear feet of wall. Frequency levels should be at 50 to 60 hertz ± 5 percent.	**6.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
7. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**7.** Interior finish--Class A or B only. Corridor finish--Class A only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**7.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance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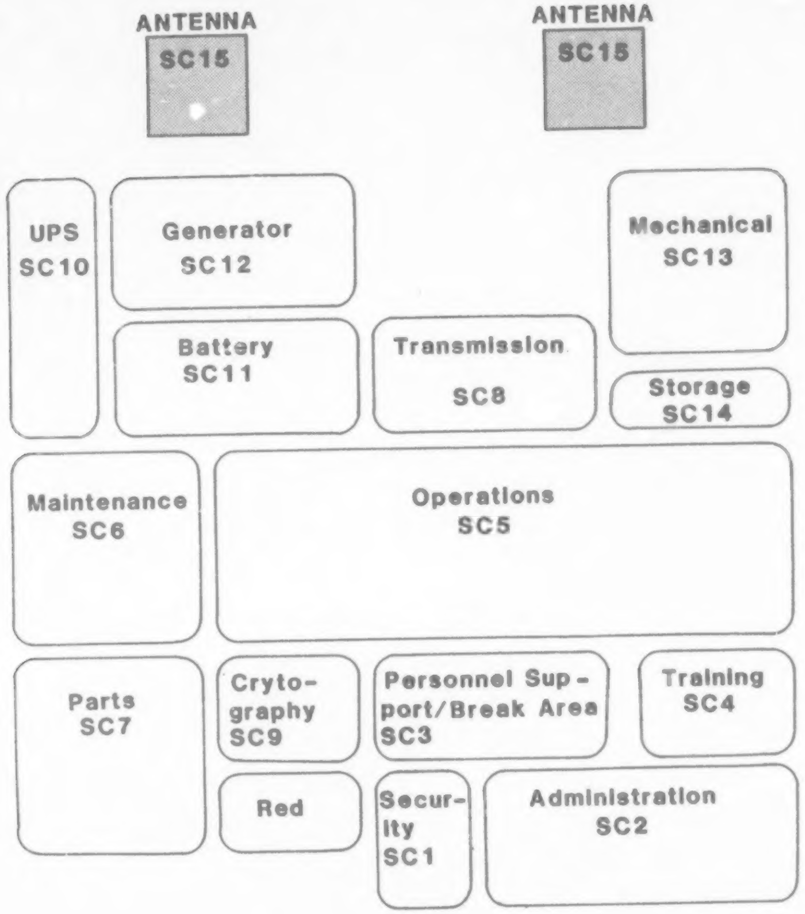
guidance

ANTENNA SC15



function

The antenna sends communications data to, and receives it from, synchronous satellites and terrestrial users.

policy/sop

1. All facilities shall be designed to have a minimum useful life of 15 years when exposed to ambient environmental conditions at the selected site(s). Facilities that support technical equipment shall be designed for 24-hour-per-day operation, seven days a week. The initial operations and maintenance (O&M) personnel complement for the terminal is estimated at one person for each of three shifts per day. (55) 7

2. Height limitations imposed by airfield clearance requirements and local zoning restrictions should be investigated during the siting process. (51) 3

3. The earth terminal antenna beam path must have a clearance of at least 5 degrees elevation above horizon obstructions throughout the earth terminal's sector of satellite visibility. (38) 3-4

4. For sites in the northern hemisphere, the earth terminal should be located on the south side for all buildings. Generators and any other auxiliary equipment should be sited north of the antenna. This layout should be reversed for sites in the southern hemisphere. The satellite's orbit should be considered in laying out the site. Since there are no plans for satellites other than those in equatorial orbits, a multiple terminal site generally should have terminals placed in a north-south line; however, for terminals at the greater latitudes (approximately 40 degrees or higher), terminals should be placed in an east-west line--this will prevent one terminal from screening another. A minimum separation of 360 feet between earth terminals should be maintained to reduce the possibility of radiation hazards and RFI. (38) 3-4

5. Communication satellite earth terminals should be sited to minimize EMI to the earth terminal from other radiation sources and to minimize EMI to other electronic devices in the general area. The extremely low levels of the RF signals received by the Phase I earth terminals from Initial Defense Communications Satellite Program (IDCSP) satellites require that extraneous EMI be considered carefully in site selection. Similarly, the relatively high power of the signals transmitted from earth terminals requires careful consideration of possible EMI to nearby electronic equipments. (38) 3-10

   In site selection, both kinds of EMI should be considered, particularly in the azimuth sector involved in the expected area of sky coverage. (38) 3-10

policy / sop

Particular emphasis should be placed on establishing the maximum signal levels of any RF signals found to exist within the receiving frequency band of 7.25 through 7.75 gigahertz. If any major signals are found, calculations should be made to insure that their field intensity and modulation characteristics will not cause unacceptable degradation to receiving subsystem performance. (24) 48

6. The area between the perimeter fence and the technical building should be lighted for security and personnel safety. The level of lighting depends on security requirements at the selected site. In areas where mechanical equipment (e.g., antenna) is located, the level shall be a minimum of 20 footcandles. (55) 11

7. Pavement around structures shall be sloped to provide drainage away from the buildings. Before erecting antennas, an area within a radius of 50 feet shall be made suitable for the all-weather operation of heavy construction equipment such as cranes. (23) 3

8. Lightning protection shall be in accordance with NAVFAC DM-4 Design Manual, Electrical Engineering; the National Electric Code; and NFPA Pamphlet 78-1968, Lightning Protection Code. (42) 18-11

   A lightning rod with proper grounding shall be installed at the top of the radome if it is not already provided. (38) 3-18

9. Area around antenna site should be designated as RESTRICTED airspace.

issues and assumptions

1. Radomes

Local environmental conditions may require a radome to be installed. The need for a radome will be determined by site requirements. DCA approval is required before radome installation. (57) 2

2. Hazard sources

Some major EM hazards are: the intended fields emitted from radar and communications antennas, especially types that concentrate EM energy into directed beams; extraneous radiation from cables and structures; and unintended X-radiation from any device in which voltage levels exceed approximately 10 kilovolts, especially microwave and other electron tubes or devices using high plate voltages. (41) 5-30

Antennas can be grouped into two general classes: omnidirectional and directional. Omnidirectional antennas radiate energy in all directions simultaneously. They are used chiefly in mobile communications, broadcasting sources, Identification, Friend or Foe (IFF), and similar equipment that require broad area coverage. Omnidirectional antennae rarely present a hazard (at least to personnel) for two reasons: (1) the energy emitted is so spread out that power densities seldom reach hazardous proportion (a notable exception to this is the case of the region immediately surrounding a very high power broadcast antenna), and (2) the operating frequencies used are not absorbed by the body. Directional antennas, on the other hand, radiate energy in relatively narrow lobes or beams that extend out from the antenna in one or, at most, a few directions. They are used for transmission between two fixed points, as in HF communications and microwave relays, and for the many types of radar in use today. Because of their directional characteristics, that is, the concentration of EM energy into narrow beams, and because of their use at extremely high powers, this antenna category forms the major source of hazardous EM fields. (41) 5-30

Ground and structural reflections can add to the main beam and cause a power density value that is four times the free-space value. Thus, fields at the threshold of hazardous levels in the absence of reflections can become hazardous when reflection occurs. The direction and type of polarization of the electric field vector also plays a role in determining the nature and extent of interaction between the field and personnel or materials. (41) 5-34

3. Interconnecting cable lengths

Locations for equipment inside each earth terminal are limited by the lengths of interconnecting cable furnished with the terminal. Interconnect cables for the AN/TSC-54 are 50 feet long and 100 feet long for the AN/MSC-46; both equipment types have longer power cables. (For semipermanent installations, the power leads can exceed the length of the equipment power cable provided the proper size of wire is used for the distance and power frequency. (38) 3-4

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issues and assumptions

4. Foundations for antenna mount and radome

The antennas' heavy weights, pedestals, and requirement for accurate pointing make reinforced concrete foundations necessary. The size of these foundations will vary among locations depending on the soil characteristics and climate extremes expected. All semipermanent earth terminal installations will include radomes to protect the antenna, antenna pedestal, and associated equipment. These radomes are relatively heavy and require reinforced concrete foundations. A radome foundation should be centered on the antenna pedestal's vertical center of movement. Again, refer to technical manuals for the specific equipment to be installed, giving due consideration to environmental properties of the selected site. This background is essential to installation plan development. (38) 3-12

The area between the antenna foundation and the radome foundation should be paved and sloped outward (1/4 inch per foot) to the radome foundation. Drains for tie-down hallows and the overall enclosed area should be provided if warranted by expected climatic conditions. (38) 3-13

5. Ambient EMI environment

This environment is important to system performance and should be investigated during the early stages of site selection. Particular emphasis should be placed on establishing the maximum signal levels of any RF signals found within the receiving frequency band of 7.25 through 7.75 gigahertz. If any major signals are found, calculations should be made to insure that their field intensity and modulation characteristics will not cause unacceptable degradation to earth terminal complex performance. (23) 2

6. HEMP protection design versus no protection

The cable trench should be able to withstand vehicular traffic and should be designed to carry the waveguide runs, signal cables, and technical ground run to the antenna for the AN/GSC-39 in a way similar to that for the AN/FSC-78. To harden the trench to HEMP, an entry plate will be used at each end of the trench (facility and pedestal base) to which all waveguides and cable shields will be bonded circumferentially. In addition, the entry plate should be attached to the facility rebar. Rebar in the trench should be connected to the building and pedestal rebars. These designs are to supplement the details of required trench construction shown in USACEEIA-CED STD-SS001. These criteria also are to be included in the required construction of the trench as an integral part of the antenna support structure. (57) 20

The antenna foundation must be constructed with the rebar cadweld-bonded to anchor bolts, to which the pedestal is attached. The foundation rebar must be connected electrically at all intersections. (57) 20

issues and assumptions

7. AN/FSC-78(V) versus AN/GSC-39(V-1)

Facility specifications and requirements for the AN/FSC-78(V) SCT are very similar to those of the AN-GSC-39(V-1) fixed terminal complex. The main difference is antenna size--60 feet diameter for the AN/FSC-78(V) versus 38 feet for the AN/GSC-39(V-1). (1) 156

8. General site preparation considerations

The various interconnect cables and equipment coolant piping should be protected. Environmental conditions at the earth terminal site decide if cables and piping should be installed in shallow, protected trenches or on elevated, protected hangars. Drainage features should be included for both types of cable runs. (38) 3-18

Special precautions should be taken to insure the earth terminal's continuous operation under expected environmental conditions. For areas that have hurricanes or typhoons, special provisions for tie-down anchors and other precautions against high-velocity winds should be taken. Air-conditioning and fungus prevention may be required in hot, humid locations. Similarly, special heating and ventilation should be used in cold areas. Normal construction procedures for any particular area should be followed with due consideration given to the sizes and weights of the earth terminal's major units. (38) 3-18

9. Multiple antenna sites

The identification system adopted for dual antenna sites with a north-south orientation is as follows: antenna 1 is the southernmost antenna and antenna 2 is the northernmost antenna. At sites with three antennas, the one located at right angles and midway between antennas 1 and 2 is designated antenna 3. At dual antenna sites that have an east-west orientation, antenna 1 is the eastern antenna and antenna 2 is the western antenna. (36) 2-1

10. Antenna assembly

Until the antenna is completely assembled, a clear area with a minimum radius from the antenna bases is required. This radius depends on the type of antenna installed; for example, the minimum radius for AN/FSC-78(V) is 100 feet.

requirements	criteria	commentary
1. Hazard criteria levels.	**1.** Although every effort must be made to protect personnel and materials from exposure to hazardous levels of EMR, it is neither necessary nor desirable to impose restrictions on antenna radiation. Such actions tend to restrict operations, maintenance, and test procedures that could otherwise be carried out in safety, provided adequate precautions are taken. (41) 7-91	
2. EMR hazard control.	**2.** Adequate indoctrination and training in EMR hazard precautions are essential for all personnel engaged in installation design, as well as in equipment operation, maintenance, and testing. It is particularly important that personnel be aware of their specific responsibilities in executing safety and protective measures. In addition, rigid control must be exercised to insure that proper instructions, protective equipment, warning signs and alarms, and other control methods are available to, and used by, all personnel involved. (41) 7-91	
3. Personnel hazards control.	**3.** Hazards to personnel can result from events such as direct exposure to EMR, X-rays inadvertently produced in electronic equipment, shocks and burns by RF potentials induced in various metallic objects that may be contacted by personnel, and exposure to laser radiation. Precautionary measures should be used in the design solution to minimize or eliminate hazards to personnel that could result in direct or indirect injuries. (41) 7-92	
4. Fuel hazards control.	**4.** In areas where gasoline will be handled, avoidable sources of EMR that can cause ignition normally should be located at a distance determined by good safety practices. This is usually at least 200 feet for gasoline and at least 50 feet for other flammables. These EMR sources include cargo handling vehicles, locomotives, power equipment, electrical equipment not specifically approved for use in hazardous atmospheres, all motor vehicles, and electronic and transmitting equipment and antennas. (41) 7-101	
5. Special safety precautions during EMR measurements.	**5.** Due to the potential danger to measurement personnel, special safety procedures and precautions must be followed to prevent harm and provide accuracy.	
6. Soil bearing capacity.	**6.** This requirement varies with specific antenna systems.	
7. Protection of waveguides, reflectors, and horns.	**7.** See Vol 2, SB8, Survivability.	

requirements	criteria	commentary
8. Cable trench.	**8.** The length and construction of the cable trench are very important for system performance. It is best to use the shortest cable run while maintaining a grade change between the antenna base and the transmitter room of no more than ± 3 percent.	
9. Technical ground.	**9.** Most antenna systems require a grounding system of 1 ohm or less. The ground cable is sized at 4/0 with copper-clad steel ground rods 10 feet long, 3/4 inch in diameter. All connections should be Cadweld. Rebar or wire mesh in the concrete pads will be tied to the ground system. All newly constructed concrete slabs for antenna pads, building floors, etc., shall incorporate an equipotential ground plane consisting of 6 AWG copper-clad steel wire mesh welded or brazed to the grounding system, and 1/0 AWG bare stranded copper wire risers. Refer to Figures 2 and 5 of MIL-STD-188-124 for details. (39) 4	
10. Lighting.	**10.** Fluorescent lighting shall not be used in the immediate vicinity of the antenna or inside the radome if one is installed. (92) 12.1-65	
11. Antenna characteristics.	**11.** There is a wide range of antenna systems from which to choose and each has specific design criteria for its relationship to the facility building(s) and site. The antenna system is chosen based on the facility's mission.	

guidance

1. Hazard criteria levels

Personnel

EMR--NAVMED adopted the personnel limit of 10 milliwatts per square centimeter for continuous exposure in 1957. The intermittent exposure criterion of 300 millijoules per square centimeter per 30-second exposure period was established for exposure by rotating- or scanning-type antennas and is derived from the 10 milliwatts per square centimeter figure. This permits higher levels of exposure for shorter periods of time (less than 30 seconds) up to a limit of 100 milliwatts per square centimeter for 1 second in a 30-second period. Both of these figures are based on present knowledge, with consideration given to the tolerable rise in tissue temperature. (41) 5-34

X-Radiation--The limits given in Table SC-1 for X-radiation were established by the Bureau of Medicine and Surgery. They are based on long experience with persons working in a known radiation environment and reflect dose levels that, in light of present knowledge, will not cause appreciable injury to an average individual at any time during a normal lifespan. As additional knowledge is gained concerning the biological effects of X-radiation, particularly for low-level exposures, the values listed are subject to revision. (41) 5-34

TABLE SC-1. X-RADIATION MAXIMUM LIMITS FOR PERSONNEL.* (41) 5-35

Type of Exposure	Exposure Period	REM Dose Not to Be Exceeded
Whole body, head and trunk, active blood-forming organs, gonads or lens of the eye.	Calendar quarter	3
	Permissible accumulated dose after 18th birthday.	5 (n-18) where n = age in years
Skin of whole body, or thyroid	Calendar quarter	10
	Year	30
Hands and forearms, or feet and ankles	Calendar quarter	25
	Year	75

*For current information, use latest issue of MIL-P-24014.

guidance

Fuels

The "safe" limit of exposure for fueling operations and fuel storage is based on highly limited present knowledge of minimum voltage required for arcing and has not been generally accepted as the definitive criterion. The complete characterization of hazards to fuels probably would require that a complex, worst-case, formula be developed that relates the parameters of fuel flammability limits, minimum gap spacing, and spark energy-time dependence. Due to the complexity of the variables that must be defined, development of this formula is not likely. (41) 5-35

Nevertheless, in assessing and reviewing the hazardous characteristics of fuels, the following information must be considered relative to gap distance and energy and duration of arc. (41) 5-35

From actual measurements of voltages and currents on aircraft located on a carrier deck near an energized antenna, a volt-ampere product of 50 or more was required to ignite gasoline vapor in a test device. It should also be noted, however, that only 120 volts are necessary to draw an arc (that is, to touch two electrodes and then separate) and that inductive surges energized by low-voltage sources can yield enough voltage to produce sparks. (41) 5-35

2. EMR hazards control

The following general precautions should be taken to preclude potential hazards: (41) 7-91

a. When test procedures require free-space radiation, the radiating antenna will be positioned so as to avoid directing energy beams toward inhabited structures or other personnel gathering places, fueling, ordnance, and electronic material handling areas. In positioning such radiating antennas, care will be taken to avoid reflecting either the primary beam or associated side lobes in a way that creates potential hazards.

b. Aircraft using high-power radars, vans, and other vehicles that contain radiating antennas shall be parked or shall have their antennas oriented so that if equipment is energized, the resultant beam is directed away (or into absorbent chambers) from areas for personnel, fueling, and electronic equipment/ordnance storage handling and operating.

c. When feasible, all transmitting antennas (that is, fixed) as well as those on mobile vans and associated with transportable equipment, should be located to minimize exposures in areas adjacent to or inside the installation.

d. All rotating antennas should radiate only when rotating. If necessary, further restrictions can be imposed, such as sector blanking (that is, installation of cut-out devices in the electrical or mechanical components of a system to automatically end transmission when the antenna is pointed in a predetermined

guidance

direction) or by instructing operating personnel not to transmit in certain azimuths and/or elevations.

e. All nonrotating antennas should be trained and elevated away from inhabited areas, fueling systems, and/or ordnance and electronic equipment operating, storage, and handling areas.

f. Suitable standard radiation hazard warning signs should be posted to designate potentially hazardous areas.

g. In situations for which operations would be unduly restricted by implementing the above methods and those described later, power density levels can be attenuated suitably by shielding.

h. Exposure will be avoided in all areas for which the radiation power levels are greater than 0.01 watt per square centimeter. The safe distances required for persons in the direct beams of selected radar sets are listed in NAVELEX Handbook 0101, 106. This is the distance at which the radiated power density in the beam center is 0.01 watt per square centimeter when the equipment is operated at its rated output. (42) 1-5

i. Dummy loads shall be used when practical during tuning, testing, or repairing RF transmitting equipment. (42) 1-5

j. To reduce the likelihood of inadvertent radiation hazards, a transmitter power cut-out cam is provided. These cams should never be set for an elevation angle of less than 7.5 degrees. (38) 3-10

3. Personnel hazards control

EMR--All areas in which the power density is predicted or measured to be above 10 milliwatts per square centimeter should be considered potentially hazardous and are subject to the following precautionary measures. (41) 7-92

All such areas shall be posted properly with the standard warning sign. personnel should not be permitted in these areas except under emergencies. When the possibility of accidental exposure still exists, a person should be stationed within view of the transmitting antenna and in communication with the radar operator while the antenna is radiating.

Minimum safe distances from radar antennas shall be maintained by all personnel. The minimum safe distance from specific radar antennas and the maximum exposure times within these distances under certain modes of operation are listed in NAVWEPS 16-1-529 and NAVSHIPS 0900-005-8000.

Burns and shock hazards due to EMR--EMR from antennas of electronic equipment can induce voltages in a variety of metallic objects (such as smokestacks, railings, aircraft, ladders, transmitting and receiving antennas, cranes, and booms) which can result in shocks or burns to personnel.

guidance

personnel should be alert at all times to the possibility of burns and shocks from these examples and similar objects not specifically mentioned. They also should anticipate the undesirable effects that might result from accidental shock, such as violent reactions that can cause a fall from an elevated position or an injury due to striking an object. In addition, the following safety precautions should be taken. (41) 7-101

- Circuits in electronic equipment should be grounded to protect against shocks or burns. If the protecting ground is not located in the immediate vicinity of working personnel, suitable warning tags should be used to prevent it unauthorized removal.
- Aircraft should be grounded in accordance with the latest requirements, as should mobile vans containing transmitting antennas.
- When cranes, booms, or cargo handling equipment is used near transmitting antennas, insulated hooks and other safety devices should be used.

4. Fuel hazards control

Fueling sites and operations should not be located near antennas. An ungrounded automobile, ungrounded filling nozzle, or merely the attendant's body in close proximity to transmitting antennas may produce sparks that will ignite gasoline vapor when the nozzle comes into contact with the tank opening. Pump nozzles must be grounded at all times, and motor vehicles being fueled must also be grounded before opening the tank. (41) 7-102

No flammable mixtures or materials shall be located or handled in an area for which the EMR radiation level exceeds the 10 milliwatt per square centimeter personnel exposure level. In addition, all transmitters that have antennas within a certain minimum distance of shore-based handling or fueling areas shall be deenergized as follows: (41) 7-102

- Transmitters with 250-watt or less radiated output shall be deenergized if their antennas are 50 feet or less from handling or fueling areas.
- Transmitters with more than 250-watt radiated output shall be deenergized if their antennas are within 200 feet of handling or fueling areas.
- Radar transmitters that have antennas within 200 feet of the handling area, regardless of their output power, shall be deenergized if it is possible for the center of the main beam of radiated EM energy from their antennas to fall directly on any part of the handling or fueling area.

guidance

In instances for which space limitations may dictate erection of fueling stations, parking ramps or other structures near an antenna site, the following precautions are to be observed.

- All metal used in building wooden structures located within 200 feet of fixed antennas that radiate 250 watts or more shall be bonded together when feasible and grounded to reduce interference and fire hazards.
- During gasoline or JP-4 fueling operations within the vicinity of shore-based transmitting antennas, especially high-power antennas, particular care should be taken to adequately ground all automobiles, aircraft and other gasoline, JP-4, or LPG-powered machines while they are being fueled. In addition, refueling trucks, pumps, filling nozzles, and tanks will also be grounded before any fuel delivery.

If possible, radiating antennas (i.e., rotating, scanning, and fixed) shall be positioned to prevent illumination of fueling areas in operation. Otherwise, the minimum distances given above shall be used.

Additional guidance for potential fuel hazards may be found in NAVELEX 0101,103.

5. Special safety precautions during EMR measurements

Personnel measuring a potentially hazardous field will be in some danger. The first step that should be taken to minimize such danger is to operate the radiating systems at a known reduced power. The field pattern can then be defined and the reduced power density values recorded. Proportional relationships are used to calculate the maximum power density at the same point in the pattern when the radiator is operated at its maximum power. (41) 7-104

A second precaution should be exercised in all radiation measurements. Measurement personnel should study the site plan and predicted radiation pattern so that a suitable starting point well away from the radiator(s) is chosen. This starting point should have less than the maximum predicted power density and subsequent measurements should be made by moving toward the radiating source(s). personnel should be cautioned that the maximum power density will exist at some calculated distance from the radiator so they will be constantly alert for abrupt energy level changes in the near field. (41) 7-104

Most radiation measuring devices use a directional antenna that must be pointed toward the source to be measured. Users of such devices must be instructed to scan potential reflectors as well as the primary radiators when measuring the reflected energy, especially when operating at reduced power. The tendency may be to neglect these secondary sources because of their apparently low power density, forgetting that when the same reading is used to establish the maximum power level, a hazardous condition might be indicated. (41) 7-104

guidance

Measured power density levels should be recorded on a site plan for comparison with predicted levels. Considerable care should be taken to picture the site in three dimensions when comparing levels and assigning hazardous labels to particular areas. Highly directive antennas may have their major beams crossing a particular area such that a hazard appears to exist, but upon considering a difference in vertical angles, the hazard may disappear completely. (41) 7-104

Any extreme difference between measured and predicted levels should not be disregarded because it may signal inaccuracies in the prediction process. In any case for which doubt arises, the measured value should be given precedence in decision making. The combination of measured and predicted results should be real factors in the final determination of existing hazards. (41) 7-104

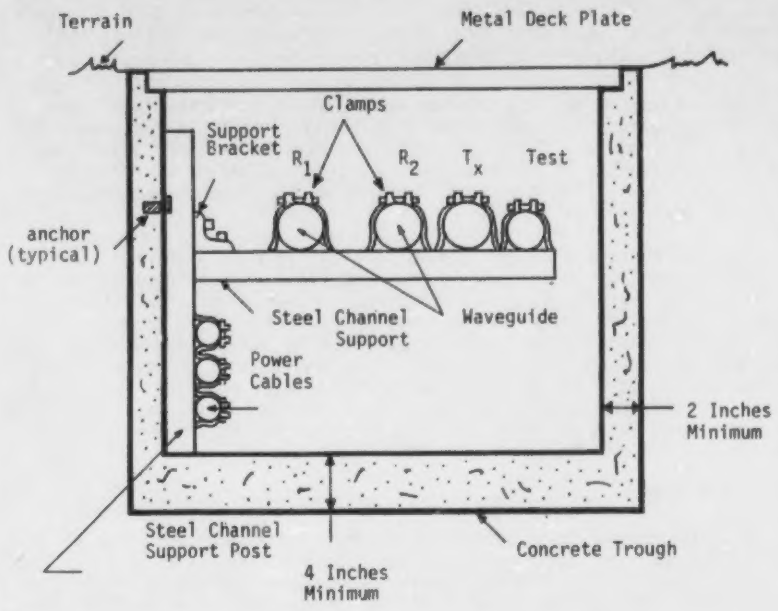
When a radiation hazard survey and analysis is complete, certain discrete areas may be defined on the site plans as hazardous to personnel, fueling operations, or electronic or ordnance devices. Steps must then be taken to convey the warning to using personnel as well as to itinerants. Warning is commonly provided by the standard signs described earlier. Fences and other obstacles or more active deterrents (interlocks, cut-outs, or delay mechanisms) often must be installed to alleviate the hazardous condition. Care must be taken in using these methods since some of them may have direct bearing on the functional utility of the systems involved. (41) 7-104

8. Cable trench

A cable trench is required to connect the underfloor area of the technical equipment room to the antenna support structure. Figure SC-6 shows details of the required construction; AFCC LDBWS01182AD000 gives the details. The cable trench shall be constructed as an integral part of the antenna support structure. The trench has not been designed to support vehicular traffic; therefore, it is recommended that the site layout not have roads crossing the trench. If site requirements dictate a road crossing, cable trench covers shall be modified by the construction project. The cable trench shall be designed so that no water stands in the bottom; it shall be sloped to a sump or allowed to drain naturally. If a sump is required, a sump pump shall be installed during cable trench construction. The area around the trench shall be graded to preclude surface drainage water from entering. The Government will construct this cable trench. (23) 3

The length of the waveguide run from the transmitter filter assembly in the transmitter room to the center of the associated antenna is important to systems performance and should not exceed the nominal 100 feet. Elevations for the raised floor of the transmitter room and the finished floor in the antenna base shall be selected so that the grade between them will not exceed ± 3 percent. This implies that the relative orientation of the technical building and antenna should be maintained. (23) 2

guidance



Note:
Dimensions of the concrete trough are variable within limits to allow ease of access and installation.

FIGURE SC-3. CABLE TRENCH. (52) 2-44

guidance

11. Antenna characteristics

AN/FSC-78

The AN/FSC-78(V) is a fixed-site, high-capacity, heavy-route communications terminal. Operating in the military X-band frequency range, it is a multiple carrier, full 500-megahertz instantaneous bandwidth terminal with both 70 and 700 megahertz IF interfaces. Having a receive figure of merit (G/T) more than 30 decibels, it uses available satellite power efficiently to maximize overall system capacity. The terminal provides simultaneous transmit and receive carrier operation, with configuration of up to 9 up-link and 15 down-link carriers. Frequency selection is synthesizer-controlled in 1-kilohertz increments and is provided across the full operating bands. The terminal frequency stability of ±3 x 10 to 12 is controlled by atomic frequency standards. (24) 41

Flexibility to meet changing communication requirements is inherent in AN/FSC-78(V) design. Carrier handling capability is selected for a given terminal by inclusion or deletion of modular up- and down-converter equipment and associated items as required. (24) 41

The AN/FSC-78(V) is a link between the RF interface with the satellite and the IF interface with the multiplexed baseband signals modulated with the intelligence to be communicated. The 70- and 700-megahertz interfaces can accommodate a variety of baseband modulation, multiplex, and code techniques. Since the users may be located remotely, an interconnect feature, such as land lines, microwave facility, or fiber optics, may be required to collect and distribute voice and data channels to and from the baseband units. (24) 42

The AN/FSC-78(V) consists of the antenna structure with its elevated equipment room and supporting technical operations building. The pedestal structure is a standard elevation-over-azimuth design with yoke and kingpost. A spokeless elevation wheel permits a nontilting elevated equipment room to be mounted directly behind the feed, supported by the yoke arms. The weatherproof, environmentally controlled equipment room contributes greatly to operational availability by permitting maintenance of off-line, antenna-mounted electronics during system operations. Antenna characteristics are: (24) 45

- Diameter: 60 feet
- Form: High efficiency parabolic
- Optics: Cassegrain
- Surface variation: 0.030 inch root mean square
- Position readout: Two-speed synchronous
- Stow lock: Remote operation

guidance

- Elevated equipment room (EER): 100 square feet, nontilting
- Access (any antenna position): Stairs, platforms
- Deployment: 45-day field erection
- Survival (not stowed): 30 mile per hour winds + 53 mile per hour gusts, any operating position. (Stowed): to 150 miles per hour nonoperating
- Radome: Not required
- Pointing accuracy: ±0.050
- Life expectancy: 15 years.

AN/MSC-46

The AN/MSC-46 is an air-transportable, medium terminal contained in seven vehicles. The entire terminal can be carried in a C-5A aircraft and can be erected without heavy equipment. It is a multiple carrier, full 500-megahertz instantaneous bandwidth earth terminal. The frequency synthesizer control, slaved to an atomic frequency standard, provides tuning to 1-kilohertz steps over the full transmit and receive bandwidths. Extensive equipment redundancy is included to achieve a high degree of availability. (24) 50

The AN/MSC-46 consists of the antenna structure with a tripod support and associated equipment and support vans. The location and use of the terminal may allow the equipment to be installed in buildings rather than vans. (24) 51

The antenna tripod supports the tower and antenna yoke. The RF room, attached to the yoke by elevation sector gears, forms the support for the antenna reflector. This design precludes maintenance on RF room equipment during terminal operation. Figures SC-4 and SC-5 show details. Antenna characteristics are: (24) 51

- Diameter: 40 feet
- Type: Parabolic with dielguide feed
- Reflector surface tolerance: 0.65 inch from parabolic
- Subreflector surface tolerance: ±0.30 inch from hyperbolic
- Tracking accuracy: 0.04 degree up to 89.5 degrees elevation

guidance

- Wind loading during operations:

  Without radome: 30 miles per hour with gusts up to 60 miles per hour

  With radome: 80 miles per hour with gusts to 120 miles per hour

- Ice loading: 1 inch over half of surface
- Number of carriers: Up to 6 transmit, 15 receive
- Soil requirements: To accommodate a load of 4000 pounds per square foot and bulk modulus of 250 pounds per square inch
- Ground: A single point ground system with a resistance of one ohm or less
- Lighting: Fluorescent lighting fixtures with integral RF interference filters (G.E. No. 89G635, Sprague IF-37, or equivalent).

The power required for the AN/MSC-46 terminal is 120/208 volts ±5 percent, 3-phase, 4-wire, 60-hertz. Average power consumed is 140 kilowatts. The three diesel-engine generators of 100 kilowatts each, which are supplied with the equipment, should be installed as emergency power backup. (38) 3-16

guidance

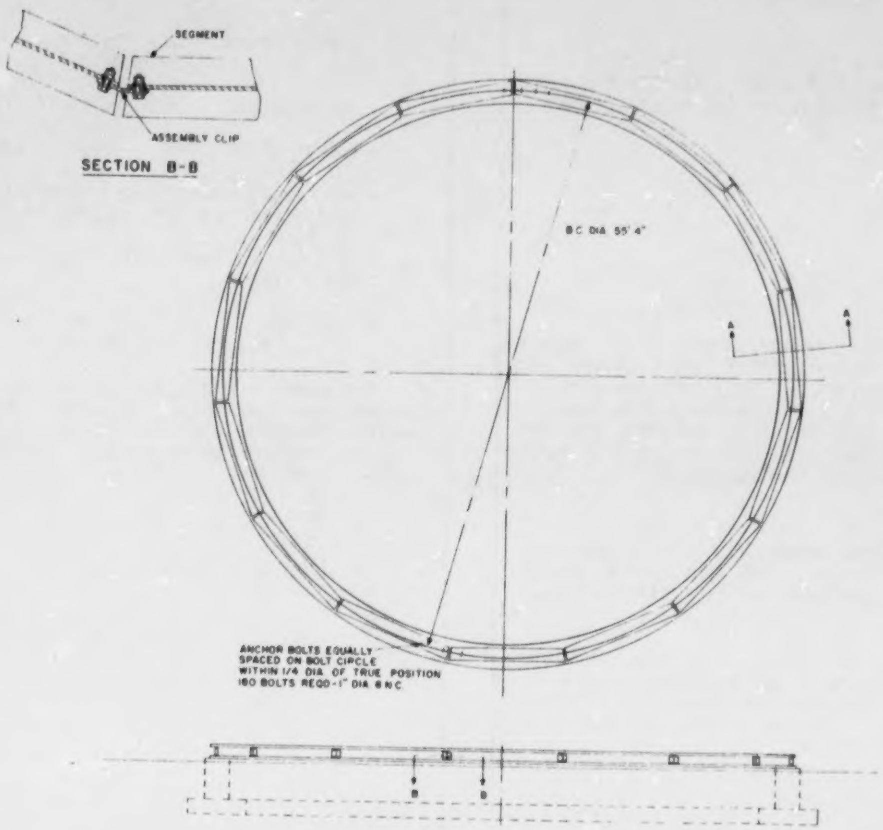
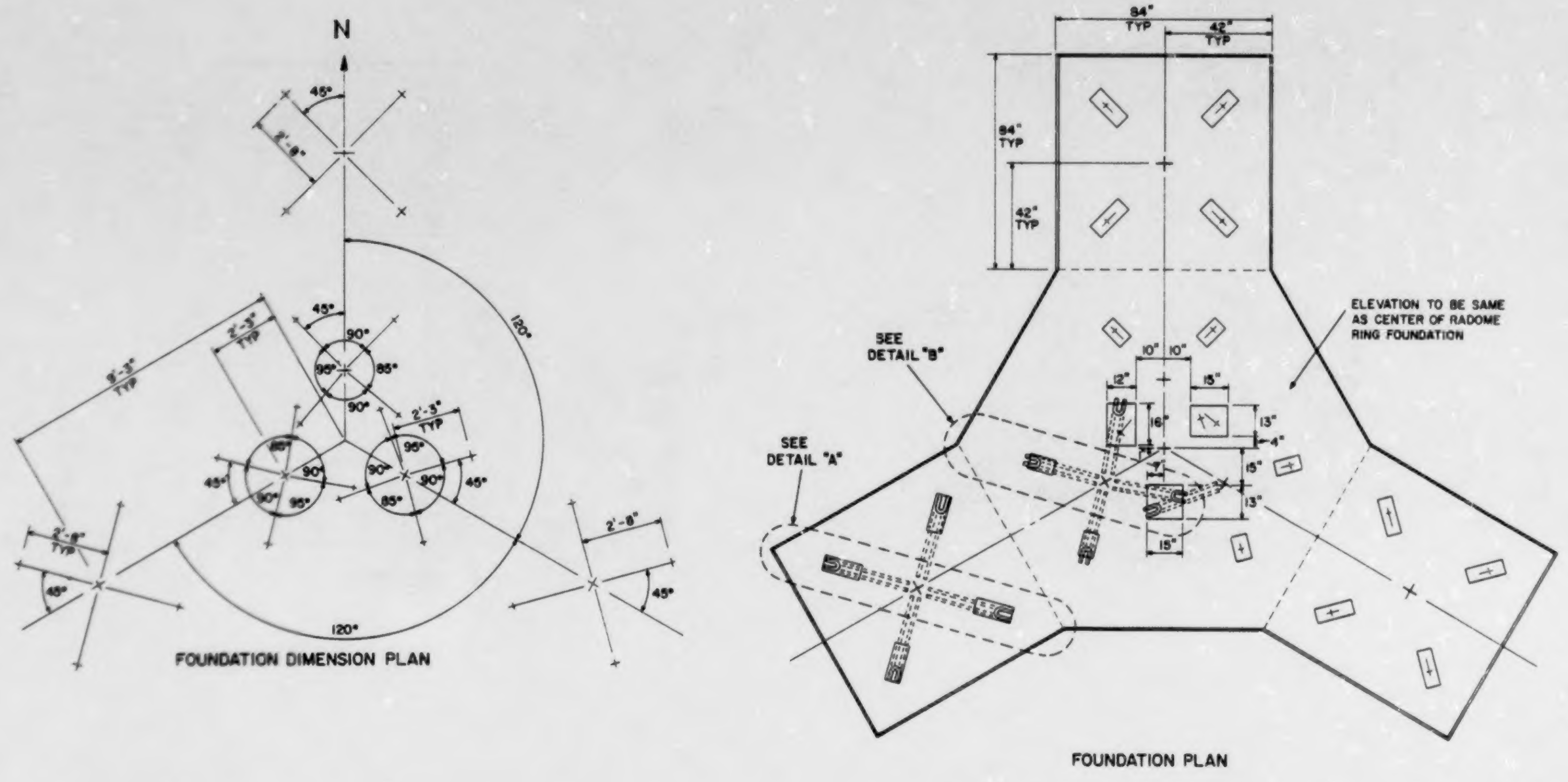

SEGMENT
ASSEMBLY CLIP
SECTION B-B
B C DIA 55' 4"
A
A
ANCHOR BOLTS EQUALLY SPACED ON BOLT CIRCLE WITHIN 1/4 DIA OF TRUE POSITION 160 BOLTS REQD-1" DIA 8 N C
B
B

FIGURE SC-4. TYPICAL FOUNDATION FOR RADOME FOR AN/MSC-46 ANTENNA. (38)
FO 3-3

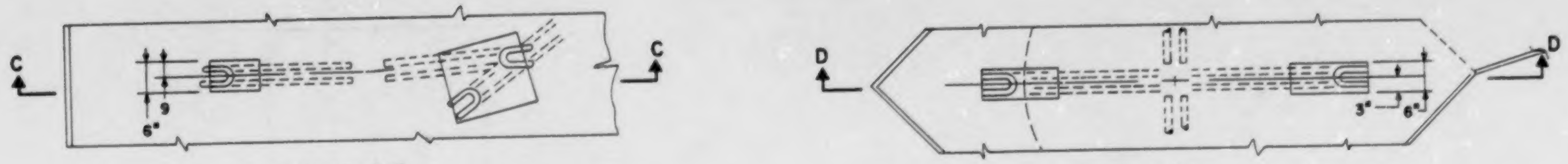

N
45°
2'-9"
120°
45°
90°
95°
95°
90°
9'-3" TYP
2'-3" TYP
2'-3" TYP
95°
90°
90°
45°
45°
90°
95°
95°
95°
90°
2'-8" TYP
45°
2'-8"
45°
120°
84" TYP
42" TYP
84" TYP
42" TYP
ELEVATION TO BE SAME AS CENTER OF RADOME RING FOUNDATION
SEE DETAIL "B"
SEE DETAIL "A"
10"
10"
12"
15"
16"
13"
4"
15"
13"
15"

FOUNDATION DIMENSION PLAN

FOUNDATION PLAN

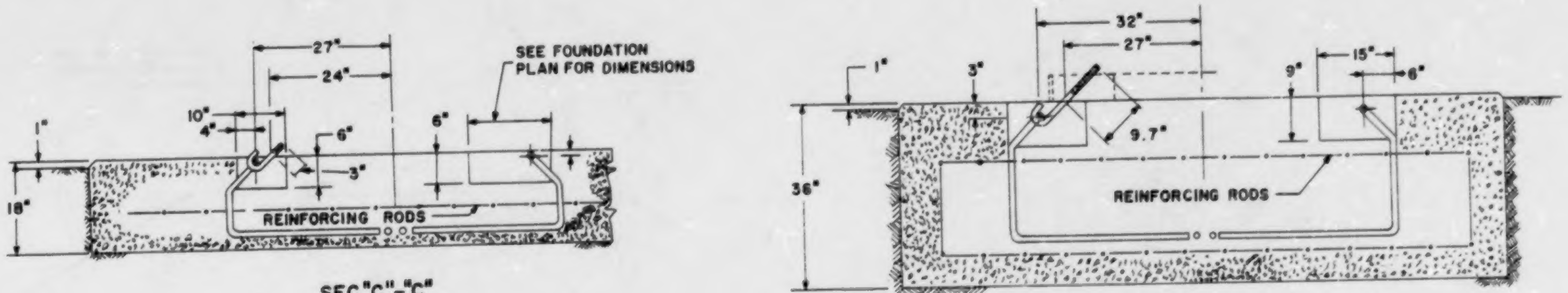
FIGURE SC-5. TYPICAL FOUNDATION FOR AN/MSC-46 ANTENNA PEDESTAL.
(38) FO 3-I

guidance



DETAIL "B"

DETAIL "A"


27"
24"
SEE FOUNDATION PLAN FOR DIMENSIONS
10"
4"
1"
6"
6"
3"
18"
REINFORCING RODS
32"
27"
1"
3"
9"
15"
6"
9.7"
36"
REINFORCING RODS

SEC "C"-"C"

SEC "D"-"D"

FIGURE SC-5. (CONT'D). (38) FO 3-2

guidance

AN/GSC-39

The AN/GSC-39 is a multiple carrier, 500-megahertz bandwidth earth terminal designed for medium capacity service in the DCSC Phase II system. It has 70-megahertz wideband interfaces and will process a variety of baseband modulation, multiplex, and coding techniques. The electronic communication equipment is identical to that used in the AN/FSC-78 terminal. The AN/GSC-39 antenna group is composed of a 38-foot parabolic reflector supported by an elevation-over-azimuth mount using a dielguide, monopod, five-horn feed system. The earth terminal can be carried in two 32-foot standard vans for transport and recovery or it can be installed in a permanent fixed facility using a standardized building configuration. (24) 56

The AN/GSC-39 is a link between the RF interface with the satellite and the IF interface with the multiplexed baseband signals modulated with the information to be transmitted. An interconnect feature, such as land lines, microwave facility, or fiber optics, may be required to collect and distribute voice and data channels to and from the baseband equipment. (24) 57

The AN/GSC-39 is configured either in a van or as a fixed terminal. The van configuration can be transported by 4 C-130E, 2 C-141, or 1 C-5A aircraft. The antenna can be assembled and installed on a prepared site by eight men in seven days using a 30-ton crane with an 80-foot boom. Antenna characteristics are: (24) 57

o Diameter: 38 feet

o Form: Parabolic

o Feed: Dielguide monopod with five feed horns

o Sidelobe characteristics:

First sidelobes: -15 decibels maximum

Second and third sidelobes: -20 decibels maximum

o Wind and ice loading: Three-sigma autotracking error shall cause 0.5 decibel loss in received carrier level with a uniform 1/4-inch ice coating in 30 mile per hour average winds. An antenna can be positioned in 80 mile per hour winds with 1/4-inch ice loading

o Number of carriers: Up to 14 plus beacon receive, 9 transmit

o Design lifetime: 15 years.

guidance

The AN/GSC-39 (V)1 antenna is the Antenna Group OE-222/MSC(G/T-34) manufactured by the Harris Corporation. The Antenna Group has a diameter of 38 feet, is 43 feet high, and weighs 70,000 pounds. The G/T-34 antenna can operate in steady winds of 63 miles per hour and must be driven to stow in winds in excess of 81 miles per hour. (57) 2

Figure SC-6 shows a grounding plan and foundation layout.

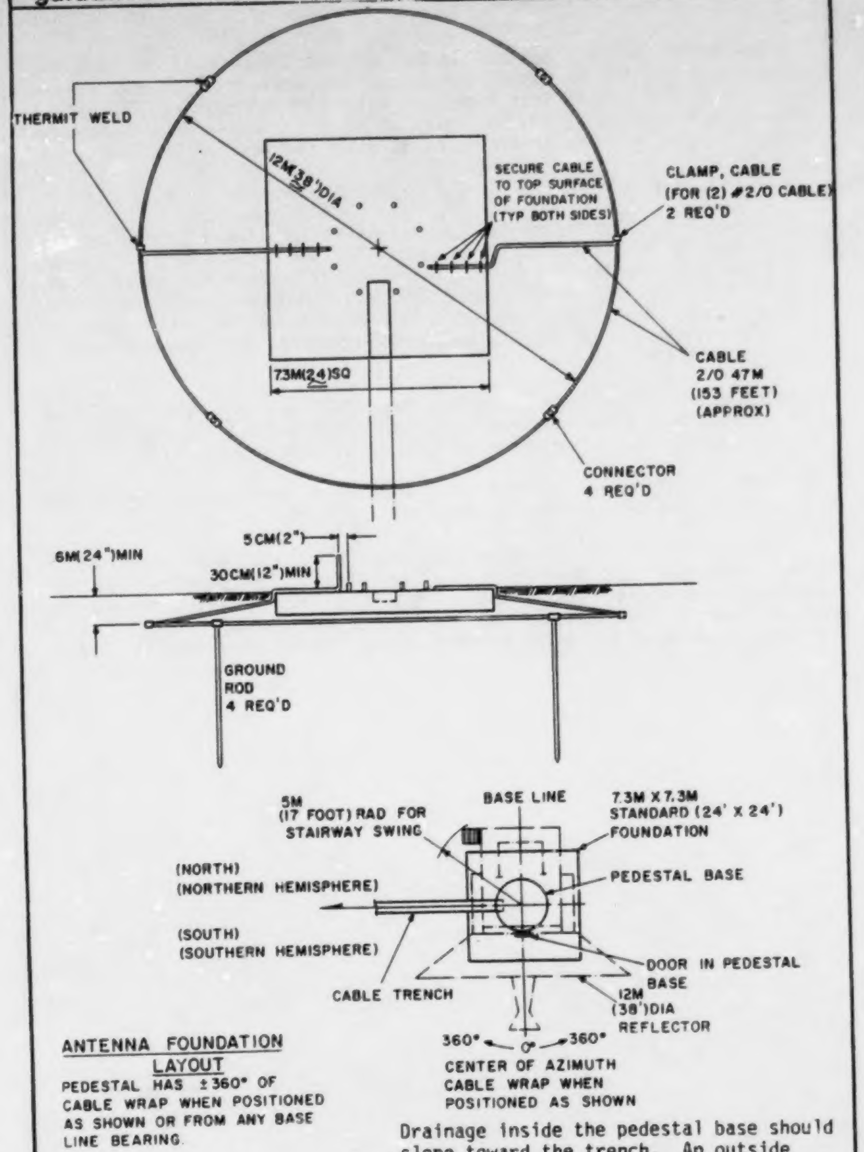
Radome--Local environmental conditions may require a radome for the AN/GSC-39 (V)1 antenna. The radome for the G/T-34 antenna is the Electronic Space Structure Corporation (ESSCO) model M68-81-9008. This is the same model radome planned for future AN/MSC-46 sites. The need for a radome will be determined by site peculiar requirements. Radome implementation requires DCA approval before installation. (57) 2

Topographic conditions--Ideally, the AN/GSC-39 (V)1 site should be located on a relatively high, flat area not subject to flooding with an unobstructed view to the horizon in all directions. (39) 3

Soil conditions--A minimum soil bearing of 1000 pounds per square foot is required for the antenna pad. (39) 3

The AN/GSC-39 (V)1 site should be oriented so that the antenna has a clear view over 180 degrees azimuth centered on the equator. In the northern hemisphere, there should be a clear horizon view toward the south from 90 degrees east through 270 degrees west. USACEEIA will obtain these data during the earth terminal complex site survey. (39) 4

guidance


THERMIT WELD
12M(38')DIA
SECURE CABLE TO TOP SURFACE OF FOUNDATION (TYP BOTH SIDES)
CLAMP, CABLE (FOR (2) #2/0 CABLE) 2 REQ'D
7.3M(24)SQ
CABLE 2/0 47M (153 FEET) (APPROX)
CONNECTOR 4 REQ'D
5CM(2")
6M(24")MIN
30CM(12")MIN
GROUND ROD 4 REQ'D
5M (17 FOOT) RAD FOR STAIRWAY SWING
BASE LINE
7.3M X 7.3M STANDARD (24' X 24') FOUNDATION
(NORTH) (NORTHERN HEMISPHERE)
PEDESTAL BASE
(SOUTH) (SOUTHERN HEMISPHERE)
DOOR IN PEDESTAL BASE
CABLE TRENCH
12M (38')DIA REFLECTOR
360°
0°
360°
CENTER OF AZIMUTH CABLE WRAP WHEN POSITIONED AS SHOWN
ANTENNA FOUNDATION LAYOUT
PEDESTAL HAS ±360° OF CABLE WRAP WHEN POSITIONED AS SHOWN OR FROM ANY BASE LINE BEARING.

Drainage inside the pedestal base should slope toward the trench. An outside pedestal base should slope away from the antenna.

FIGURE SC-6. ANTENNA GROUNDING PLAN FOR AN/GSC-39 (V-I).

guidance

guidance

Table SC-2 summarizes general antenna properties.

TABLE SC-2. PRINCIPAL CHARACTERISTICS OF DSCS EARTH TERMINALS. (38) 2-18

Equipment Parameters	AN/FSC-9	AN/MSC-46	AN/TSC-54
Physical			
Type Housing:	Permanent construction	3 vans 1 antenna 3 power units	1 shelter 1 antenna 2 power units
Terminal Weight:	--	114,000 lb	19,500 lb
Type Installation	Permanent/ground-based	Movable/ground-based	Mobile/ground-based
Transportability			
Aircraft:	--	C-130E(3)	Helicopter or C-133E
Overland:	--	Truck-transported	Ground-transported
Technical			
Power Output	Variable, 10 W to 20 kW	Variable, 100 W to 10 kW	Variable 0 W to 5 kW
Modulation:	FM and spread spectrum	FM and spread spectrum	FM and spread spectrum
Bandwidth: (max. RF base-band)	50 MHz (-3 dB)	40 MHz (-1 dB)	40 MHz (-1 dB)**
Freq Range			
Receive:	7.25 to 7.75 GHz	7.25 to 7.75 GHz	7.25 to 7.75 GHz
Transmit:	7.9 to 8.4 GHz	7.9 to 8.4 GHz	7.9 to 8.4 GHz
Communications Capacity Installed:	11 voice* 1 TTY 1 TTY O/W	11 voice* 1 TTY 1 TTY O/W	1 voice 1 TTY 1 TTY O/W
Preamp Noise Temperature	55° K	82°K	120°K
Antenna Half Power Beam Width:	0.15°	0.17°	0.5°
Size/Type:	60 ft diam, parabolic	40 ft diam, parabolic	18 ft effective diam, 4 10-ft dish cluster
Configuration:	Cassegrain feed	Cassegrain feed	Cassegrain feed
Radome:	None	Rigid, 68 ft diam***	Rigid, 41.4 ft diam****
Primary Power Requirements			
Voltage:	440 V	120/208 V±10%	120/208 V±5%
Phase:	3	3	3
Frequency:	60 Hz	50/60 Hz ±5%	400 Hz ±2%
Kilovolt amperes	750	less than 200	45

guidance

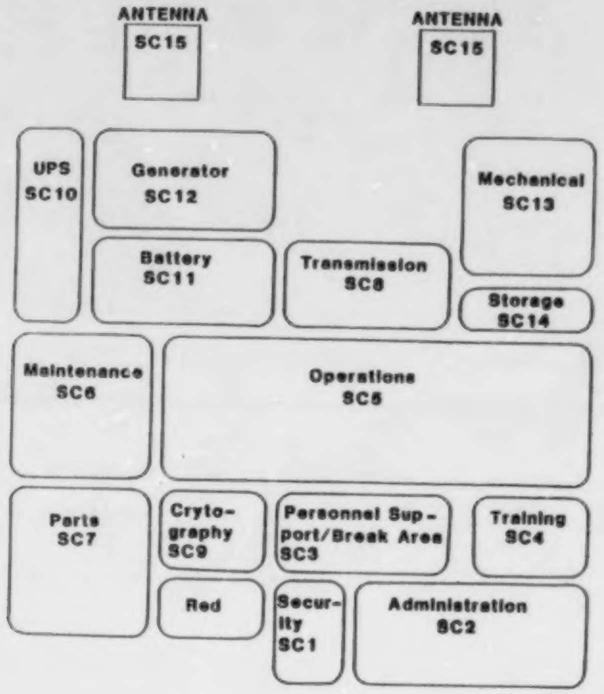
*An auxiliary wideband input of 0.3 to 500 kHz or 0.3 to 252 kHz (up to 60 voice channels) can be accommodated.

**Receive bandwidth limited by IF filter to 10 MHz, RF bandwidth is 40 MHz.

***Rigid radome is not furnished with terminal, but weight is included in total weight.

****Rigid radome is not furnished with terminal, but is used as required by environmental conditions.

STANDARDIZED MODULES SC16


ANTENNA
SC15
ANTENNA
SC15
UPS
SC10
Generator
SC12
Mechanical
SC13
Battery
SC11
Transmission
SC8
Storage
SC14
Maintenance
SC6
Operations
SC5
Parts
SC7
Cryto-
graphy
SC9
Personnel Sup-
port/Break Area
SC3
Training
SC4
Red
Secur-
ity
SC1
Administration
SC2

building design principles

1. Efficiency of operational functions
   a. Communication equipment aligned for surveillance and access.
   b. On-the-job training with operating equipment.
   c. Interaction of operational support activities.
   d. Accessibility of toilets for operations personnel.

2. Integration of parts/maintenance modules with operations
   a. Parts/maintenance modules contiguous with operations spaces.
   b. Loading dock accessibility for equipment and supplies.

3. Efficiency and accessibility of administration spaces
   a. Administration transition space between public areas and secure spaces.
   b. Efficiency of integrated administrative spaces.

4. Personnel support spaces
   a. Change of environment for on-duty personnel.
   b. Facilities available for physical training.

5. Integration of power/UPS modules
   a. Economies and efficiencies of integrated power modules.
   b. Minimized impact of generators on communications transmissions.
   c. Economical battery room ventilation.

6. Facility expansion
   a. Expansion potential in new construction operations space.
   b. Minimized impact of future operations space expansion.

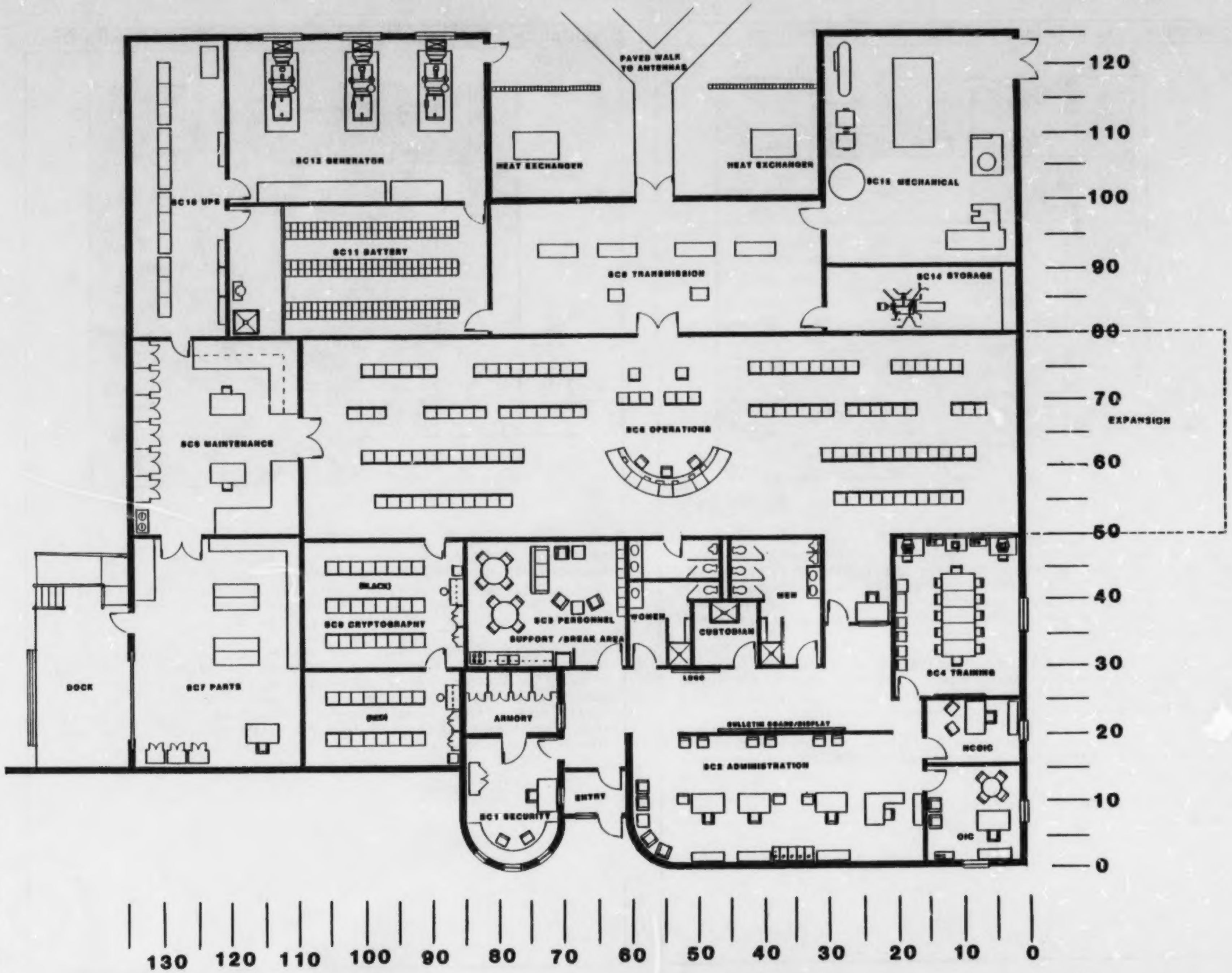
7. Security operation
   a. Location of security space to control building access.
   b. Central monitoring of total site and building security.
   c. Message security in operations and cryptography modules.
   d. Limited access into secure areas.

8. Facility security/survivability
   a. Required vault construction for communication system equipment.
   b. Protection of the communication signal.

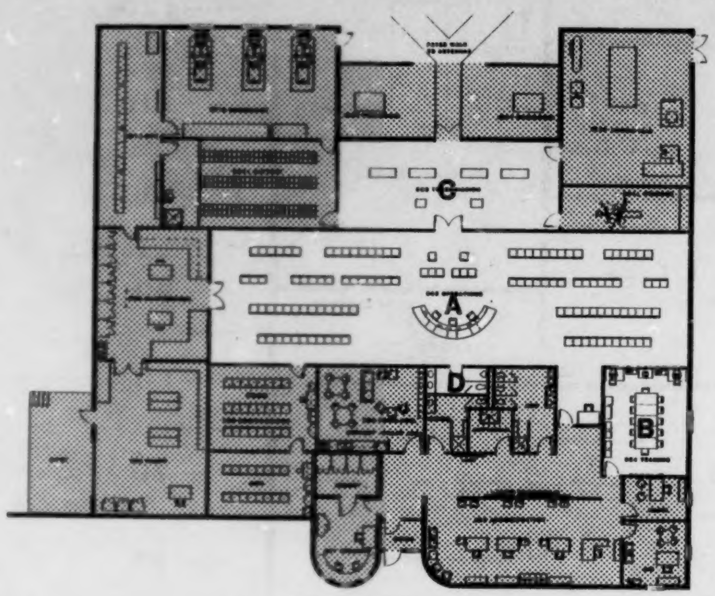
9. Fire protection
   a. Fire protection classifications: occupancy, hazard of contents, sprinkler protection, and construction/materials.
   b. Building separation distances.
   c. Fire protection systems: automatic fire suppression, automatic notification/alarm, and automatic fire detection.

10. Life Safety
    a. Occupant load determination.
    b. Protected exit conditions: exit capacities, number of exits, exit travel distances, and means of exit arrangement.
    c. Allowable interior finishes.
    d. Egress path identification: illumination of means of egress, emergency lighting, and means of egress marking.

SC-93


PAVED WALK TO ANTENNAS
SC12 GENERATOR
SC10 UPS
SC11 BATTERY
HEAT EXCHANGER
HEAT EXCHANGER
SC8 TRANSMISSION
SC13 MECHANICAL
SC14 STORAGE
SC9 MAINTENANCE
SC5 OPERATIONS
EXPANSION
(BLACK)
SC6 CRYPTOGRAPHY
(RED)
DOCK
SC7 PARTS
SC3 PERSONNEL SUPPORT /BREAK AREA
WOMEN
CUSTODIAN
MEN
LOGO
SC4 TRAINING
ARMORY
BULLETIN BOARD/DISPLAY
SC2 ADMINISTRATION
NCOIC
ENTRY
SC1 SECURITY
OIC
120
110
100
90
80
70
60
50
40
30
20
10
0
130
120
110
100
90
80
70
60
50
40
30
20
10
0

guidance 1. Efficiency of Operational Functions



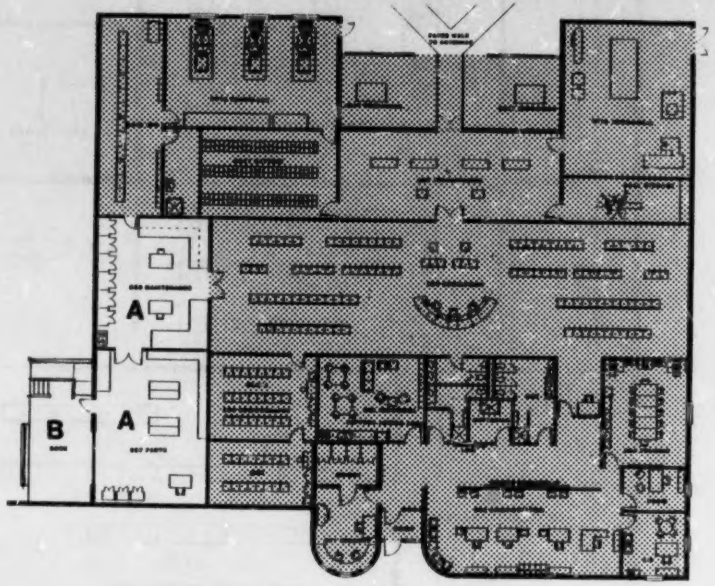
A. Equipment should be aligned in parallel rows within the operations modules for ease in visual surveillance and to provide direct access to all critical equipment. Multiple consoles should be adjacent to each other so that limited personnel can monitor them efficiently at one central location. Tables for audiovisual training aids should be available in operations modules so that personnel can train on-the-job during regular watch periods.

B. To further enhance the effectiveness of on-the-job training, instruction can be done in small groups of four or five in a training room for hands-on experience with communications equipment. This requires a close relationship with the operations module.

C. Additional building modules with a close functional relationship to operations activities should be located adjacent to the operations module.

D. Toilet facilities should be nearby for personnel in the operations module.

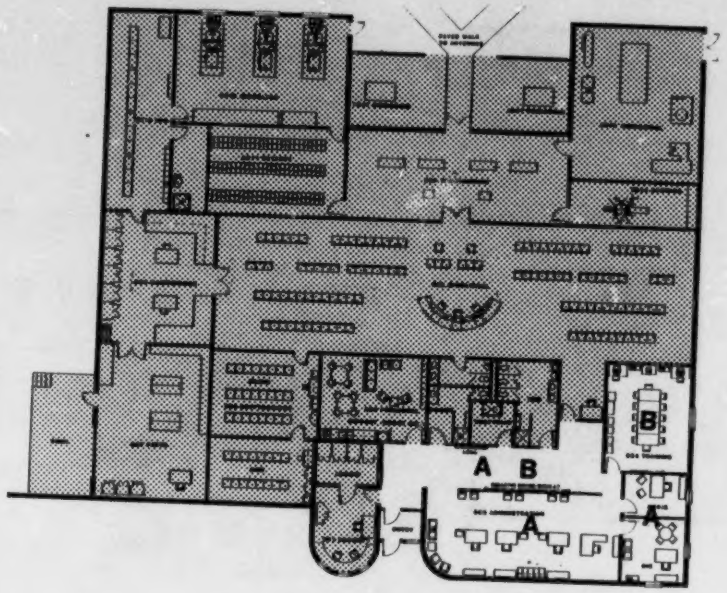
guidance 2. Integration of Parts/Maint. Modules with Ops.



A. Parts and maintenance modules should be well integrated and contiguous with the operations spaces to optimize efficiency and minimize circulation. The secure door between the operations and the maintenance/parts spaces is used only as a fire exit and to bring communication equipment in from and out to the loading dock. This door should have opening hardware only on the secure side.

B. Parts and maintenance from modules must be located within an organizational context such that deliveries can be made to the total building in a direct and secure process at a loading dock. The large communication equipment can be moved in and out more easily using the loading dock. (Also, in multistory communication buildings, an elevator should be located adjacent to the parts module for safe vertical movement of large communication equipment throughout the building.)

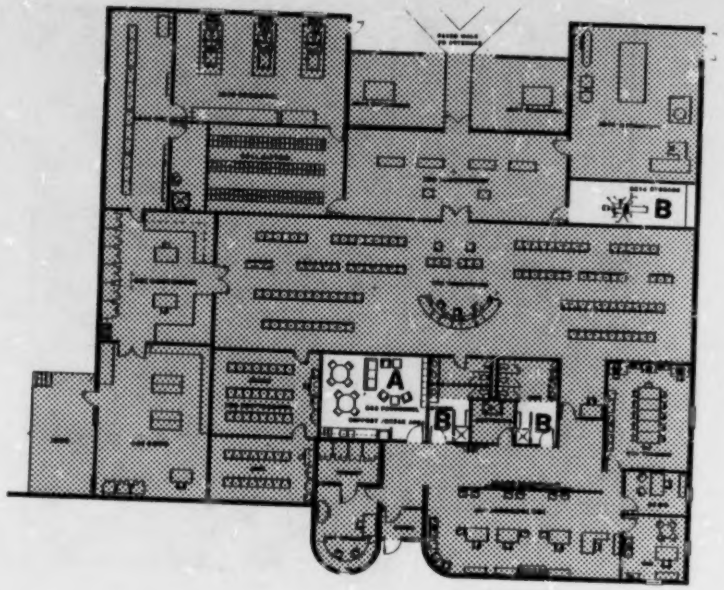
guidance 3. Efficiency and Accessibility of Admin. Spaces



A. Administration modules must be easily accessible to the public to minimize circulation and to prevent visitor interference with facility operations. The administration modules should provide a buffer and transition space between the exterior and interior secure spaces. Also, public corridors in the administration area should contain military unit logos and other display panels that relate to the "esprit de corps" and unit integrity of the communication station.

B. Administration spaces' integrated relationship will improve efficiency by minimizing public and administrative circulation and by producing a group adjacency to shared conference areas, secretaries, and waiting areas.

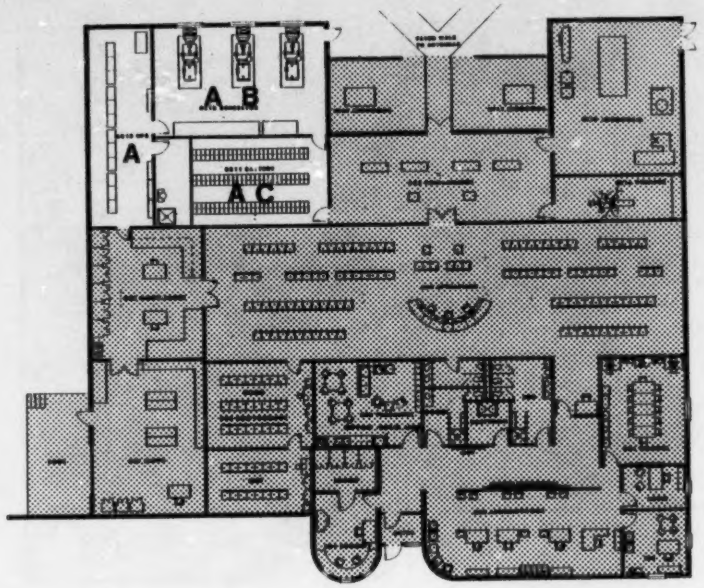
guidance 4. Personnel Support Spaces



A. The intense activities inside the DCS facility tend to generate mental fatigue among personnel. It is therefore necessary to create a change of environment for on-duty personnel to provide a break from the "hard surface" equipment room and work areas. The personnel support module should be directly adjacent to the operations room, but isolated acoustically and visually.

B. In addition, physical exercise equipment is recommended for DCS facilities located off military bases. The necessary showers and lockers should be similarly adjacent to the operations module for easy access and optimal use.

guidance 5. Integration of Power/UPS Modules

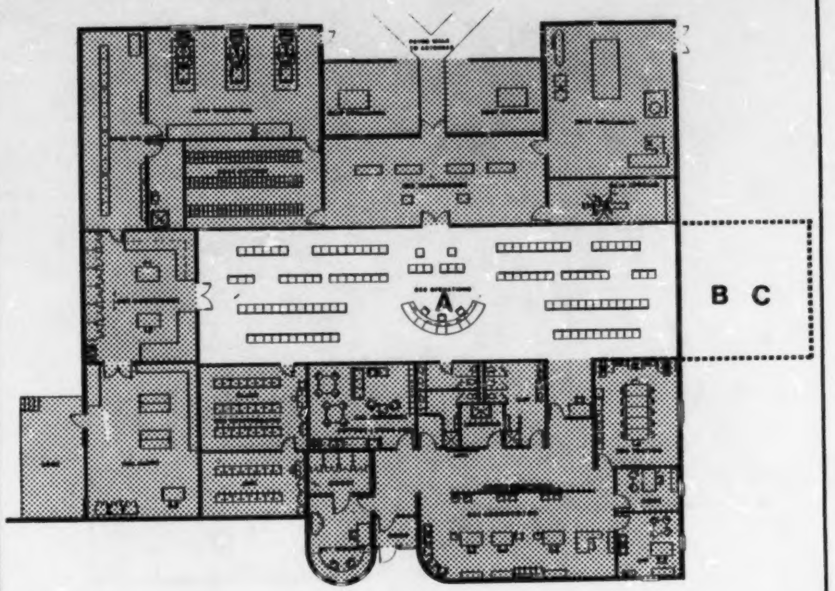


A. Modules that comprise the power and UPS gear should be contiguous and well integrated. Direct physical adjacencies provide economy by minimizing cable lengths and produce personnel efficiency through interaccess relationships.

B. Confining the power and UPS spaces to remote areas will minimize the impact of generator vibrations that could adversely affect the communications transmission.

C. Direct exterior ventilation of the battery room can be more energy efficient if the make-up air is conditioned by ducting through (or coming directly from) other utility rooms (generator, UPS, or mechanical modules). Thus, interior battery rooms are acceptable, when the ventilation supply air is ducted through an adjacent room and the ventilation exhaust air is ducted through the roof.

guidance 6. Facility Expansion

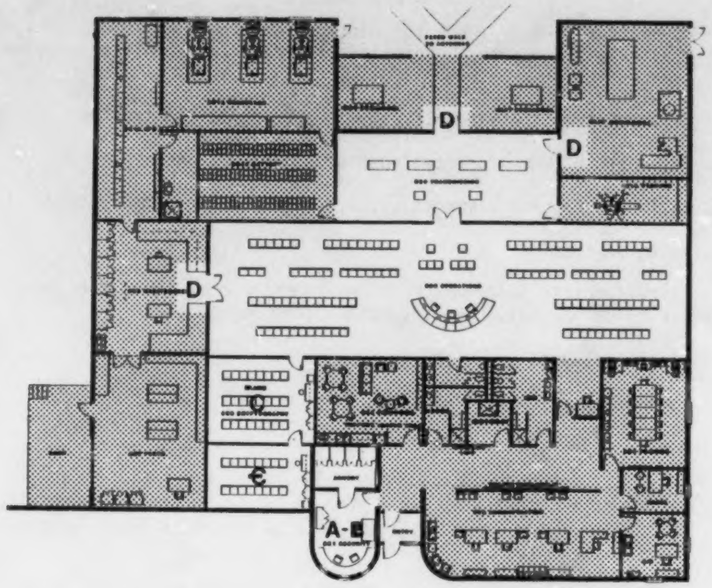


A. The equipment layout should be planned in a way that affords enough space for the installation of equipment capable of handling the maximum projected traffic load. The initial equipment layout should be such that the station facility's ultimate expansion can be done without extensive rearrangement of existing equipment.

B. Operations modules should be functionally isolated from support and power modules. Because of the increasingly rapid changes in communications technology, new demands on the spatial layout of operations modules can be expected in the future. Such spaces must be able to expand to accommodate new equipment and new functions. It is not anticipated that support and power spaces will need this same expansion capability and, therefore, may be located in their own areas; that is, facility design should allow operations modules to expand without greatly affecting the remaining functions.

C. A facility must be able to respond to major changes in mission or functional requirements such as the addition of other modules (for example, a "Technical Control" or a "Patch and Test"). Thus, the facility must be able to adapt to mission expansion.

guidance 7. Security Operation



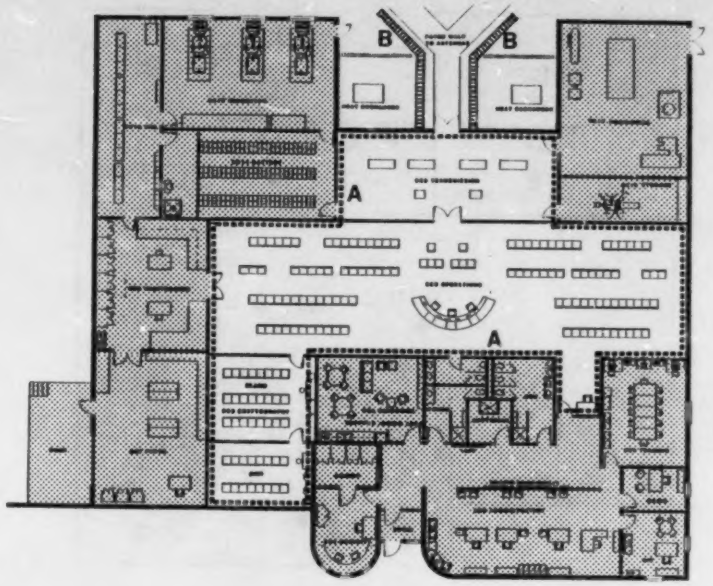
A. Security modules should be located to provide an overview for entry verification of visiting personnel. Additionally this module must be easily accessible to building occupants to facilitate efficient storage and distribution of weapons for personnel.

B. The security module will administer site security, monitor all intrusion detection systems, and initiate proper reactions to hostile threats. The security module should therefore be designed to provide overview and control over both site access and all exterior activities.

C. "Message" security is achieved by minimizing circulation between operations and cryptography modules, confining the modules to controlled areas, and providing disposal techniques to be performed or controlled by authorized personnel.

D. Required doors from other interior modules or from the outside that open into secure areas should have opening hardware only on the secure side.

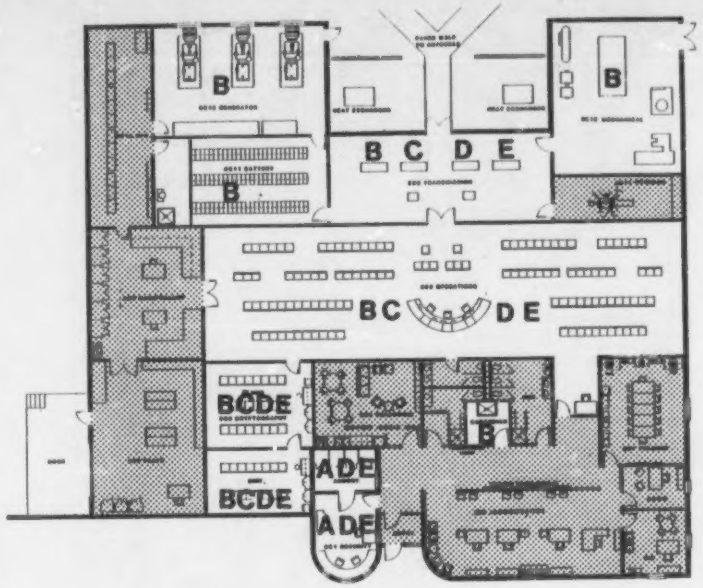
guidance 8. Facility Security/Survivability



A. Conventional Class A vault construction is required for all spaces containing the communication system equipment--for example, operations, equipment, and tech control. Therefore, efficient construction methods and future building flexibility requirements can be met by locating these spaces in a contiguous relationship. These spaces usually require vault-type construction for a combination of four requirements: (1) HEMP protection, (2) TEMPEST shielding, (3) building intrusion resistance, and (4) fire protection. (See SB7, Security Systems--guidance for building security construction of Zone 4, Section 5b in Vol 2).

B. Communication facilities require waveguides in transporting the communications signal to and from the transmission/receiving equipment antennas. It is therefore necessary that the transmission/receiving module be located at a minimal distance from the antennas. In addition, waveguides must be physically protected to insure the facility's ability to perform its mission.

guidance 9. Fire Protection



Occupancy classifications: Business (NFPA); B-2 (UBC)

Hazard of contents classification: Ordinary hazard

Sprinkler protection classification: Ordinary hazard--group 2.

Construction classifications/materials for fire protection (See Vol 2, the first figure in SB3, Fire Protection/Life Safety)

A. Type II--fire resistive (UBC) for security/armory spaces:

Construction Element	
Exterior walls	4-hour rated construction
Interior bearing walls	2-hour rated construction
Structural frame	2-hour rated construction
Permanent partitions	1-hour rated construction
Shaft enclosures	2-hour rated construction
Floors	2-hour rated construction
Roofs	2-hour rated construction

B. Type II--One-Hour (UBC) for battery, cryptography (RED/BLACK),* custodian, generator, operations,* mechanical, and transmission spaces:

All construction elements.......1-hour rated construction

Type II--N (UBC) for remainder of building spaces

All construction elements.......Noncombustible construction

Building Separation

Site-specific information is required. Comply with the second figure in Vol 2, SB3, Fire Protection/Life Safety.

Interior finishes

See Guidance/Life Safety, Vol 2.

Fire protection systems

Automatic fire suppression

A water sprinkler system shall be provided throughout the entire facility.

C. A Halon 1301 or carbon dioxide system shall be provided under raised floor areas containing nonmetallic, sheathed, exposed cables when the space under the raised floor is used as an air plenum.

Automatic notification/alarm

A general alarm must be activated by the automatic sprinkler system.

D. Local alarms are required to sound only in the designated spaces; they are activated by smoke detectors.

Automatic fire detection

E. Smoke detectors are required to activate local alarms only in the designated spaces. In rooms containing raised floor areas, smoke detectors shall be located under the raised floor.

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*See Vol 2, SB7, Security, for vault construction requirements that may be more stringent than those imposed by fire protection requirements.

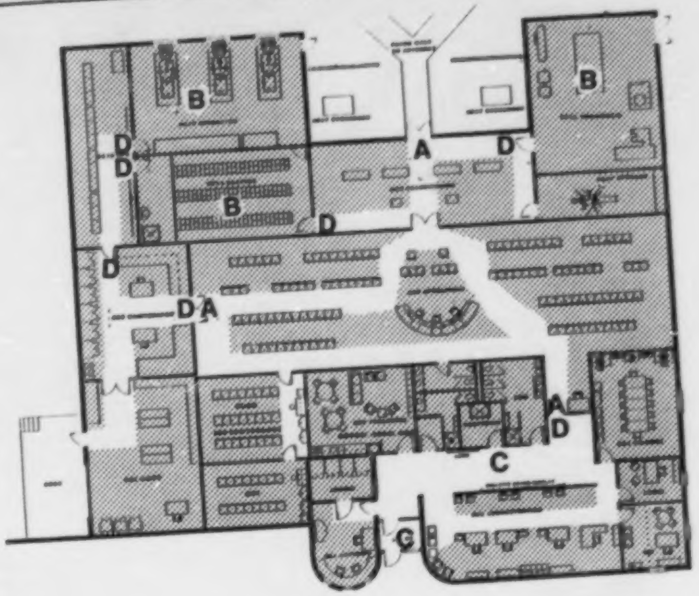


TABLE SC-3. OCCUPANT LOAD FOR DETERMINING EXIT REQUIREMENTS.

Occupant load factor: 100 square feet per person based on gross floor area (Business Occupancy-NFPA)

Occupant load (total facility) $= \frac{14740 \text{ sq ft}}{100} = 148$ persons

Occupant load (vaulted area) $= \frac{5015 \text{ sq ft}}{100} = 51$ persons

Occupant load (admin/support) $= \frac{3670 \text{ sq ft}}{100} = 37$ persons

Exit capacities

Corridors--100 persons per unit of exit width for travel in either direction. The minimum width of any exit access corridor or passageway shall be 44 inches in the clear.

Doors--100 persons per unit of exit width (a 3-foot door provides 1.5 units of exit width, providing an exit capacity for 150 persons).

Number of exits

No less than two exits shall be accessible from every part of every floor. One exit is permitted when the room or area has: (1) a total occupant load of less than 100 persons, (2) direct exit to an open area outside the building at the ground level, and (3) a total travel distance on the same level of not over 100 feet. (If stairs are involved, they shall be no more than 15 feet in height and shall be provided with complete enclosures to separate the stairs from any other part of the building.)

Exit travel distances

Required exits shall be located to allow access without passage through areas that may be locked. No dead end corridor shall exceed 50 feet. Travel distance to exits shall be no more than 300 feet when the building is protected throughout by an approved automatic sprinkler system.

Arrangement of means of egress

Exit access and travel routes to exits are shown in the plan.

A. Exit doors in vaulted areas that contain communications equipment are secured and permit egress out only. Exit access routes through vaulted areas from spaces outside the vaulted area are not permitted for security reasons.

B. Two means of egress shall be provided from higher hazard areas, including mechanical and generator spaces. Exit access from any other space may not pass through the mechanical or generator spaces (see exit marking). For security, when mechanical or generator spaces have exit access routes through interior spaces, exit access doors from these spaces, when opened, shall sound an alarm and transmit a signal to the annunciator panel in the security space. Access for normal maintenance in mechanical and generator spaces shall be through the exterior doors.

guidance

Interior finishes

C. Interior finish in exit access corridors shall be Class A only.

Interior finish in the remainder of the building shall be Class A or B only.

Means of egress lighting

Exits and exit access, including stairs, aisles, corridors, and passageways leading to an exit, shall be lighted continuously during times when the conditions of occupancy require means of egress to be available. Lighting should be no less than 1 footcandle measured at the floor.

Emergency lighting

Emergency lighting shall be provided in windowless buildings for designated aisles, corridors, and passageways leading to an exit. Emergency lighting shall stay at least 1 footcandle throughout the means of egress for 1.5 hours in the event of normal lighting failure.

Marking the means of egress

Exits shall be marked by an approved sign readily visible from any direction of exit access. Signs shall be placed such that no point in the exit access is more than 100 feet from the nearest visible sign.

D. Doors located or arranged so that they are likely to be mistaken for exits shall be identified by a sign reading "NOT AN EXIT."

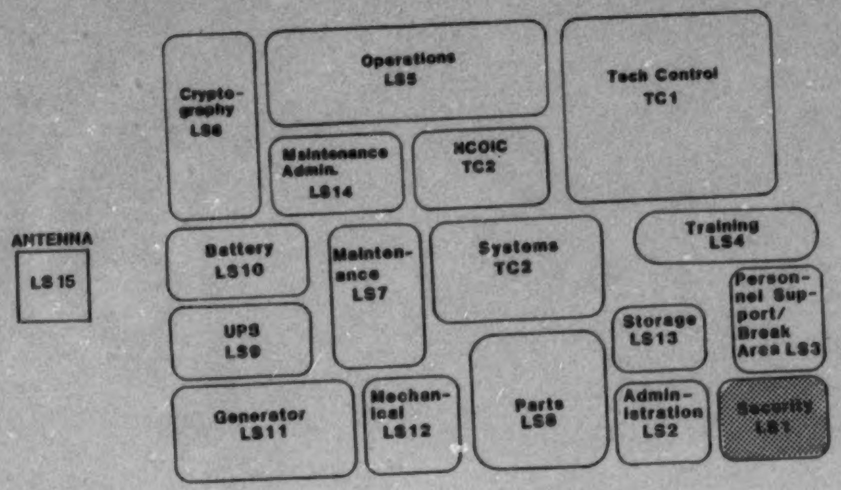
guidance

Line-of-Sight Microwave [LS]

LS1 Security LS-2
LS2 Administration LS-8
LS3 Personnel Support/Break Area LS-12
LS4 Training LS-16
LS5 Operations LS-22
LS6 Cryptography LS-28
LS7 Maintenance LS-34
LS8 Parts LS-38
LS9 UPS (Uninterrupted Power Source) LS-42
LS10 Battery LS-48
LS11 Generator LS-54
LS12 Mechanical LS-62
LS13 Storage LS-66
LS14 Maintenance Administration LS-70
LS15 Antenna Tower LS-76
LS16 Standardized Modules LS-84

Frequency-modulated microwave line-of-sight (LOS) radio systems provide a flexible, reliable, economical method of establishing point-to-point multichannel communications. When the path is mostly over land and the terrain permits the use of intermediate repeater stations, these systems can be extended for several hundred miles. Aided by suitable multiplex equipment, these systems can provide the transmission potential for many voice, telegraph, facsimile, and data channels, accommodating basebands of up to 1800 four-kilohertz channels. (70) 5-1

SECURITY LS1


Cryptography LS6
Operations LS5
Tech Control TC1
Maintenance Admin. LS14
NCOIC TC2
ANTENNA
LS 15
Battery LS10
Maintenance LS7
Systems TC2
Training LS4
Personnel Support/Break Area LS3
UPS LS9
Storage LS13
Generator LS11
Mechanical LS12
Parts LS8
Administration LS2
Security LS1

function

This component provides overview for verifying visitors before they enter the facility. The Intrusion Detection System and fire alarm equipment are monitored in this area. Also, when required, facility personnel'weapons are stored and distributed here.

policy/sop

1. The building site must withstand intrusion by individuals or groups intending to compromise the security of the information transmitted and received at DCS facilities.

2. The overall approach to providing security at DCS sites consists of five elements: (1) intrusion deterrence, (2) intrusion detection, (3) alarm assessment, (4) component and physical plant hardening, and (5) security or response force personnel. Intrusion deterrence is intended to produce a psychological state of mind in a potential intruder that intrusion will result in unacceptable counteraction. Intrusion detection is intended to provide an alarm to the operating activity or security personnel that an unauthorized intrusion has occurred at a DCS site. Alarm assessment is intended to verify that an intrusion alarm was activated by a threat against the DCS site. Component hardening of the physical security system is intended to delay the damages or to limit the amount of damage that can be inflicted on a site. Security force is intended to delay, stop, or mitigate the actions of an intruder. Every DCS site security program shall be prepared to include these five elements. (9) 4.3.3.1

3. The security alarm system should also be wired into either Tech control or the operation area spaces. These spaces will be staffed 24 hours per day, and the same personnel could monitor the security system. The receiving/administrative spaces usually are staffed only 8 hours per day during the week.

4. Most OCONUS sites have local national (LN) guards that maintain security at the perimeter fence during daytime hours. At night this function reverts to site shift communication personnel. All entry alarms should be "remoted" to locations within the operations building similar to that of closed-circuit television (CCTV) monitors. This will preclude assigning critical personnel to security duties. All alarm systems should be "remotable" to the operations console.

issues and assumptions

1. Full-time lighting versus "on-demand" lighting

Continuous lighting (stationary luminaires) is the most common security lighting system. It consists of a series of fixed luminaires arranged to flood a given area continuously with overlapping light cones during the hours of darkness. Standby lighting differs from continuous lighting in that standby lighting is intended to create an impression of activity. The luminaires are not lighted continuously, but are either automatically or manually turned on at random or when suspicious activity is detected or suspected by the security force or the intrusion detection system (IDS). This technique may offer great deterrent value as well as economy in power consumption. (37) 13.1-120

2. Automatic actuation of security lighting versus manual lighting

A deterrent lighting system can be developed to turn lights on at random or, rather than randomly activating the luminaires, an IDS sensor can be used to turn on the lights when an intruder is detected. This type of active lighting system provides maximum deterrent value at a low duty cycle. (37) 13.1-124 Automatic actuation of lights for normal operations seems most advantageous; however, manual override should be provided for control.

activities

1. Viewing personnel entering the complex.
2. Monitoring IDS equipment.
3. Operating facility physical security program.
4. Distributing and storing personnel weapons.

personnel

1. One.

equipment *

1. Pass window for identification.

2. Annunciator panel (sensor information).

3. Closed-circuit TV.

4. Gate control for perimeter security fencing.

5. Exterior lighting control.

6. Communication link to host agency.

7. Alarm for intrusion detection to host agency security office.

8. Desk (or counter unit) with chair.

9. Racks for personnel weapons. Weapon distribution is through a door with a daygate for passing through.

10. Humidifier.

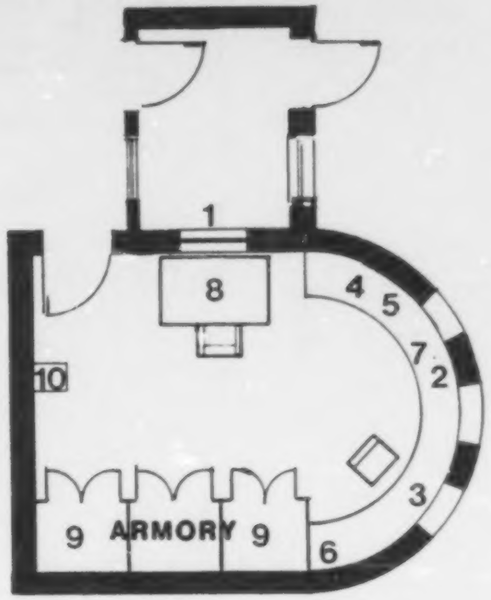
11. Intercom speaker.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate IDS equipment and personnel associated with security component.	**1.** Provide space for one person who verifies and monitors the facility's security. This area varies with size of facility, but typically is 400 to 500 square feet.	
2. Visual verification of entering personnel.	**2.** Provide a pass window.	
3. Communication and electronic monitoring lines.	**3.** Coordinate IDS components into a centralized module. Provide an annunciator panel with telephone and intercom link-ups. The operation room console should have remote alarms along with a CCTV monitor.	**3.** See SB7 Vol. 2 for additional guidance on securing doors and entrances
4. Resistance against penetration from the outside and for the armory.	**4.** Windows should be glazed and hardened to prevent penetration (bullet-proof glass). Windows also should be designed for full visibility over approaches to the point of entry.	**4.** See Vol 2, SB7, Security (Zone 3), for more information.
5. Interior finishes suitable for durability, maintenance, and room function.	**5.** Floor--Vinyl asbestos tile. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	**5.** See also Vol 2, SB2, Interior Construction and Finishes.
6. Acoustical isolation and attenuation for a nondisruptive environment.	**6.** The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum), floor surface at NRC .25 (minimum), and divider partitions (if used) at .85.	
7. Adequate lighting to review entering personnel and monitoring equipment.	**7.** Lighting shall be specially engineered. Low levels of lighting may be required to permit observation of luminous panels without reflected glare or undesirable contrasts in brightness. Separately controlled luminaires shall be provided for normally lighted operations and clean-up; this lighting should have an ambient level of 70 footcandles using fluorescent fixtures.	**7.** For further information on quality of lighting design using the ESI concept, see Vol 2, SB2, Electrical Lighting.
8. Thermal regulation and other comfort features for the occupant.	**8.** Maintain temperature at 68°F (heating) or 78°F (cooling) with a 5 cubic feet per minute per person outside air ventilation rate. A dehumidifier may be required in the armory. Provide a chair with seat height adjustment, casters, swivel, and independent back rest adjustment.	**8.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
9. Electrical power.	**9.** Provide 120/208 electrical service. 120-volt receptacles should be located for convenience at all workstations and workbenches at the appropriate height and for every 10 linear feet of wall. Frequency levels should be 50 to 60 hertz ± 5 percent.	**9.** See also Vol 2, SB2, Communication Station Buildings--Electrical.

requirements	criteria	commentary
10. Fire protection/life safety criteria are based on the assumption that this facility houses critical equipment and data that has a severe strategic fire loss potential.	**10.** Interior enclosure walls--2-hour fire-rated construction in armory, security, and entry. Interior doors--1.5-hour fire-rated doors in armory, security, and entry. Interior finish--Class A or B only. Corridor and entry finish--Class A only. Automatic fire detection--Local alarm. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**10.** See Standardized Modules-Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety for more information.

guidance



11 -- speaker in ceiling

guidance

1. Location

The minimum area is determined from IDS monitoring equipment physical dimensions.

Direct access to facility entrance is required.

This area must have no direct access to C-E equipment.

This component can be combined with the administration function in the small module package.

2. Verification

Orient windows to allow visual security of arriving personnel. In some circumstances, it works well to use mirrors to show the total front face of the building before the door is opened. This also prevents the security officer from confronting unexpected hostile action when leaving.

3. Monitoring

Three shifts in a 24-hour period are assigned for these activities if the personnel are available. At some smaller facilities, the security alarm and detection devices should also be wired into the operations, operations administration, or control monitoring space so that operation shift personnel can monitor the security system when the security space is not staffed.

Alarm system--Provide a wall-mounted alarm terminal panel in the security room. The following alarms will terminate there:

- Smoke/fire detection
- Intrusion detection of all doors and barred openings.

The termination board or its associated housing should have all alarm terminations identified clearly with permanent marking or labels. This allows future extensions of these connections to a control and fault alarm system. The alarm sensors should incorporate only dry contacts (no voltages) and should use two conductor shielded cables in the circuit runs (or in conduit) to the consolidated terminal panel noted above.

Intrusion detection system--The IDS should conform to Corps of Engineers Guide Specification CE 304.01. Provide magnetic intrusion alarm switches on all exterior doors and openings greater than 7.6 feet at the perimeter into the building. Terminate all circuits in the wall-mounted alarm panel. The door alarm is to sound then the door moves 1/2 inch toward an open direction.

guidance

The various approaches to an alarm display problem offer a wide range of capabilities, but also present several distinct disadvantages. In selecting an alarm display system for a specific installation, it is essential that the features and capabilities required for the intended application be well understood. In particular, there is no one "best" system for transmission and display of security information. Rather, a system should be selected to meet the needs of the specific installation. It should also be noted that many systems may provide more capability than is needed or desired and that paying for unused features would tend to increase the system's cost. See Vol 2, SB7, Security Systems, for more information.

4. Primary entrance door

The primary personnel entrance door should be secured with a jimmy-proof, deadbolt extension operated by a combination lock in conformance with UL Standard 768 and Military Specification MIL-L-15596. The primary entrance door should also be equipped with panic bolts and a rim with a box mullion in conformance with Federal Specification FF-H-106. The panic bolts should be UL-approved. If required for routine access control, an electrically controlled latch mechanism is authorized for installation. RF emissions should meet the requirements of MIL-STD-461 of Class II-A equipment when applicable. (5) 3-5-9

The personnel entry doors should be the steel, single-swing type with a steel frame. Another option is a door constructed of hollow metal with a 1/8-inch steel plate face.

Personnel entry doors should also be equipped with a "peephole" wide angle lens. Doors should have an inside plate to cover the peephole when it is not in use.

Hinges on both the exterior personnel and equipment doors must be welded to prevent removal of hinge pins if pivots and pins are on the outside.

7. Lighting design

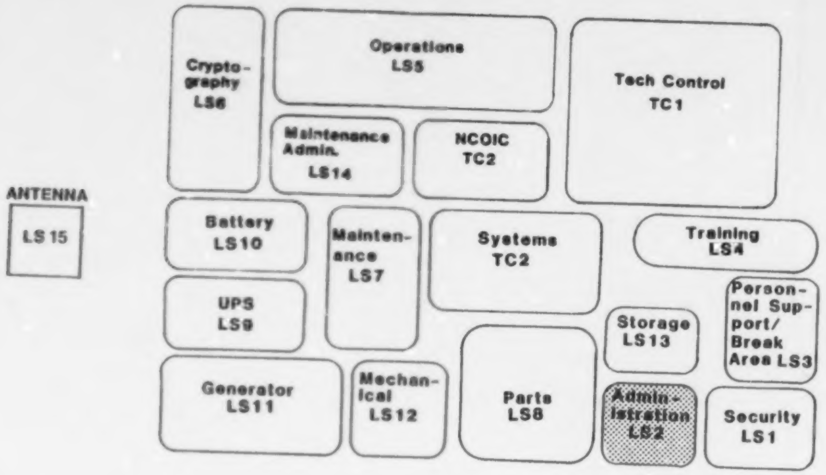
To reduce glare at video digital terminals (VDTs), use fluorescent light fixtures with specular parabolic louvers. A louver with cell dimensions of 1.5 by 1.5 inches or smaller will give a high visual comfort probability (VCP) value. A diffuser along with a parabolic louver may also be helpful. Some pigmented acrylic lenses and nonparabolic metal louver panels can also have high VCP values.

The suggested cell size for a parabolic louver is 1 by 1 inch down to .5 by .5 inch. On tall ceilings, the cell depth must be greater; this may dictate a larger cell size.

Glare from windows and reflections from walls and other surfaces must be controlled, especially on the surface immediately behind the VDT. Walls and work surfaces with a matte finish are best. Wall carpeting is also recommended for its noise control and virtual elimination of reflections.

guidance

ADMINISTRATION LS2


Crypto-graphy LS6
Operations LS5
Tech Control TC1
Maintenance Admin. LS14
NCOIC TC2
ANTENNA
LS 15
Battery LS10
Mainten-ance LS7
Systems TC2
Training LS4
UPS LS9
Storage LS13
Person-nel Sup-port/ Break Area LS3
Generator LS11
Mechan-ical LS12
Parts LS8
Admin-istration LS2
Security LS1

function

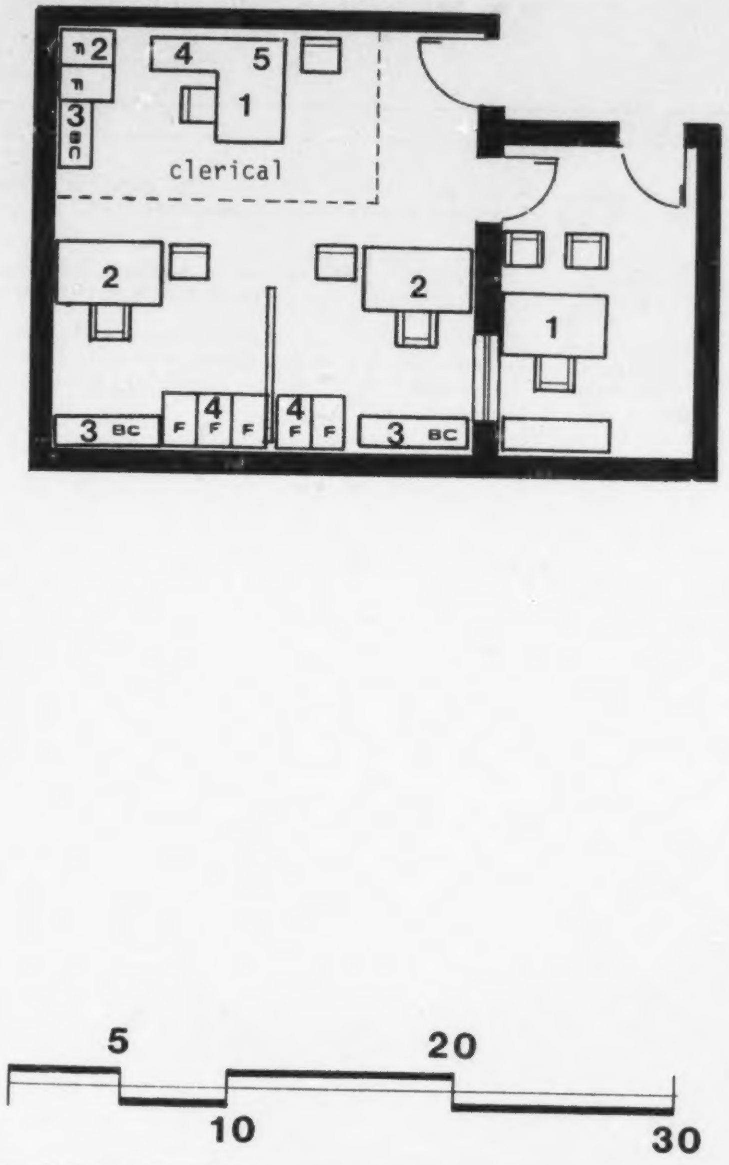
This component establishes and maintains the station administrative processing of personnel records. In addition, this section implements written and verbal SOP directives from "Chain of Command" orders, host agency regulations, and DCA policy for DCS. The administration area provides a buffer and transition space between exterior and secure interior spaces.

policy/sop

issues and assumptions	activities	personnel	equipment *
	Officer in charge (OIC) 1. Distributing directives, orders, and policy statements, both written and verbal, to shift supervisors. 2. Initiating evaluation of equipment capabilities. 3. Developing personnel training plans and equipment evaluations.	1. Site chief or OIC. 2. NCOIC and chief-in-charge.	1. Site chief workstation: Desk/chair (enclosed) Two side chairs Credenza. 2. Two NCOIC workstations: desks with chairs in open area (or with dividers). 3. Bookshelves--20 linear feet. 4. five files with five drawers each.
	Clerical 1. Typing, reception, and coordination of command/control process for the noncommissioned officer in charge (NCOIC). 2. Filing/posting of operations and personnel documents. 3. Providing courier service for paperwork.	1. One E-2 clerk (two at some installations).	1. Clerk workstation: Desk/chair (open area). 2. Two files with five drawers each. 3. Bookshelves--45 linear feet. 4. Typewriter(s)/word processor(s). 5. Operational voice intercom control. * see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate equipment and furniture associated with the administrative function.	**1.** Provide administrative space for supervisory personnel. This area varies with the number of assigned personnel, but is typically 700 to 800 square feet.	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Carpet. Base--Glazed structural units, rubber, vinyl or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation and attenuation for a nondisruptive environment.	**3.** The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum), floor surface at NRC .25 (minimum), and divider partitions (if used) at .85.	**3.** See reference 201, page 3-4, Table 3-2.
4. Adequate lighting.	**4.** Provide 80 footcandles for task lighting at work surfaces with 40 footcandles for the ambient level. Surface reflectances should be: • Ceilings--80 to 90 percent • Walls--40 to 60 percent • Floor--20 to 40 percent.	**4.** For further information on quality of lighting design using the ESI concept, see Vol 2, SB2, Electrical--Lighting.
5. Thermal regulation and other comfort features for the occupant.	**5.** Maintain temperature at 68°F (heating), 78°F (cooling), with 5 cubic feet per minute per person outside air ventilation rate. Provide a chair with seat height adjustment, casters, swivel, and independent back rest adjustment.	
6. Electrical power.	**6.** Provide 120/208 electrical service. 120-volt receptacles should be located for convenience at all workstations and workbenches at the appropriate height and every 10 linear feet of wall. Frequency levels should be 50 to 60 hertz ± 5 percent.	**6.** See also Vol 2, SB2, Communication Station Buildings--Electrical
7. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	**7.** Interior finish--Class A or B only. Corridor finish--Class A only. Automatic fire suppresion--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunicator panel and local fire department or constantly staffed station outside the facility.	**7.** See Standardized Modules--Building Design Principles and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



guidance

1. Location

Windows to the outside are recommended for CONUS facilities on secure sites, such as military installations. OCONUS facilities usually should have a minimum of windows to limit opportunities for forced entry.

Activity subspaces

- Enclosed offices
- Workstations
- Filing area
- Reception.

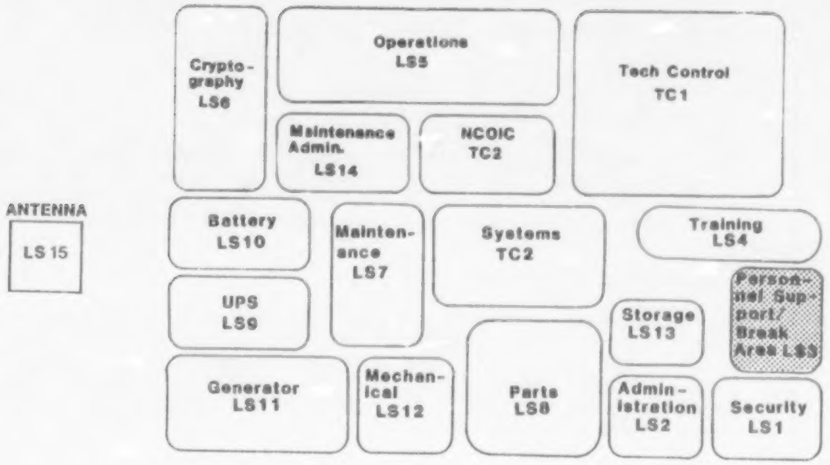
3. Acoustical and visual privacy

Divider partitions between workstations should be 60 inches high (± 4 inches) to provide visual privacy while occupants are seated--and yet should not be confining. Circulation paths around workstations should minimize disturbances to other workstations.

6. Electrical power

Workstation divider partitions can be tackboard surfaces to display maps, job examples, service equipment, and other information. Floor-to-ceiling poles are recommended to distribute electrical and communication lines to workstation modules. This eliminates floor wires at circulation paths and allows future module modifications at minimal cost.

PERSONNEL SUPPORT/BREAK AREA LS3


Crypto-graphy
LS6
Operations
LS5
Tech Control
TC1
Maintenance Admin.
LS14
NCOIC
TC2
ANTENNA
LS 15
Battery
LS10
Mainten-ance
LS7
Systems
TC2
Training
LS4
UPS
LS9
Storage
LS13
Person-nel Sup-port/
Break
Area LS3
Generator
LS11
Mechan-ical
LS12
Parts
LS8
Admin-istration
LS2
Security
LS1

function

This component creates a change of environment for on-duty personnel to provide a break from the hard-surface equipment room and work areas.

policy/sop

1. The intense activities in the DCS facility generate personnel fatigue, making it necessary to separate personnel from the communication function.

2. Current policy requires personnel to have a 15-minute break every 3 to 4 hours. Typical schedules also allow 30-minute meal breaks.

3. Most communication personnel "brown bag" their meals since they cannot leave the facility during a shift. Therefore, basic food preparation capability is required: sink, hot plate, refrigerator, cabinets, and range.

issues and assumptions

activities

1. Relaxing.
2. Reading.
3. Eating.
4. Storing food.
5. Preparing food.
6. Storing personal items such as coats and books.

personnel

1. Two to eight at once.

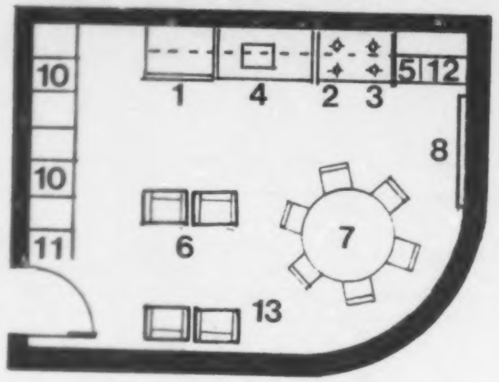
equipment *

1. Refrigerator.
2. Stove.
3. Range and range hood.
4. 20 x 30 inch sink in countertop which is a 6-foot minimum with cabinets above.
5. Coffee machine.
6. Chairs.
7. Table with chairs for eight.
8. Bulletin boards.
9. Intercom speaker.
10. Storage lockers for each person. (Not required for personnel who have private offices.)
11. Coat rack.
12. Microwave oven (if communication equipment is not affected).
13. Trash receptacles.

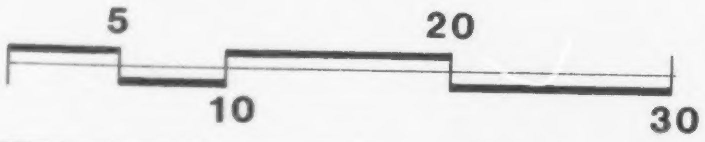
* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate equipment and furniture associated with the personnel support/break area.	1. Provide approximately 500 square feet of space for equipment and furniture to accommodate up to 15 personnel.	
2. Visual separation from the communications equipment.	2. Provide visual separation that also allows viewing of the operations area when desired. Supply comfortable furniture and carpeting (earth tones are recommended).	
3. Interior finishes suitable for durability, maintenance, and room function.	3. Floor--Vinyl asbestos tile and area carpeting. Base--Glazed structural units, rubber, vinyl or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	3. See also Vol 2, SB2, Interior Construction and Finishes.
4. Acoustical isolation and attenuation for a nondisruptive environment.	4. The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum), floor surface at NRC .25 (minimum), and divider partitions (if used) at .85.	
5. Lighting suitable for reading (task and ambient).	5. Use 20 to 30 footcandles for ambient lighting and 100 footcandles for task lighting.	
6. Thermal comfort.	6. Control temperature for 68°F (heating) and 78°F (cooling) with a 5-cubic feet per minute per person outside air ventilation rate.	6. See also Vol 2, SB2, Communication Station Buildings--Mechanical.
7. Electrical power.	7. Provide 120/208 electrical service. 120-volt outlets should be installed for every 10 linear feet of wall. Counter height outlets are required for a coffee maker, mixer, microwave oven (when permitted), and other appliances.	7. See also Vol 2, SB2, Communication Station Buildings--Electrical.
8. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	8. Interior finish--Class A or B only. Corridor finish--Class A only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	8. See Standardized Modules--Building Design Principles and Vol 2, SB3, Fire Protection/Life Safety for more information.

guidance



9 -- speaker in ceiling



guidance

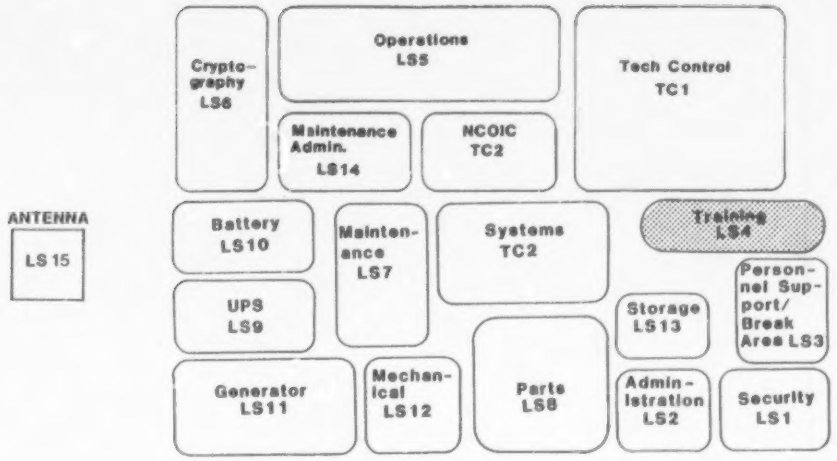
1. Location

The personnel space should be directly adjacent to the operations room, but isolated acoustically (absorptive walls) and visually (a curtain hung at the window).

3. Visual comfort

The color contrast, textures, and designs of the wall, ceiling, and floor surfaces should minimize glare for a comfortable environment.

TRAINING LS4


ANTENNA
LS 15
Cryptography LS6
Operations LS5
Tech Control TC1
Maintenance Admin. LS14
NCOIC TC2
Battery LS10
Maintenance LS7
Systems TC2
Training LS4
Personnel Support/Break Area LS3
UPS LS9
Storage LS13
Generator LS11
Mechanical LS12
Parts LS8
Administration LS2
Security LS1

function

This component is for enhancing personnel abilities and effectiveness, both technically and personally. Development and implementation of the station master training program is done here.

policy/sop

1. Technical training occurs at two levels: (1) hands-on training, i.e., working directly with the communications equipment, and (2) learning from manuals, publications, and audiovisual equipment. The physical training also occurs at two levels: (1) interior individual exercise and (2) exterior small-group recreational activities, especially at remote DCS facilities that are not on a military installation.
2. Current policy requires personnel to be allowed time to train technically while on-duty at the facility.
3. Training usually is done during the times that the communication activity is at its lowest level.
4. Some communications personnel are engaged in a Career Development Course (CDC); thus, a training area is required. The Air Force counterpart is the Quick Training Package (QTP).
5. Training usually is conducted by the shift supervisor or a lead NCO/CO who is also on-duty.
6. In fire/life/safety training, safety implies the absence and/or control of conditions that can cause personal injury, death, damage to, or loss of equipment or property. Within the system, safety is concerned with the elimination or control of factors affecting the safe and efficient operation of personnel, equipment, and facilities organized to attain a common goal. The objective of safety training therefore is to insure maximum freedom from inadvertent and possibly destructive mishaps resulting from facility equipment, procedural, or personnel deficiencies during all phases of system operation. (70) 15-30

issues and assumptions

1. Three-shift versus four-shift impact on training time available

Most facilities operate on a three-shift basis:

• Day shift	8 a.m. to 4 p.m.
• Swing shift	4 p.m. to 12 a.m.
• Midshift	12 a.m. to 8 a.m.

By having personnel assigned to four shifts instead of three, one group could be a "training shift" that would be on duty during the day shift; thus, the peak activity period would have double the personnel available if required, plus give trainees the best opportunity to interact with facility functions.

The four-shift concept, however, assumes one or both of the following:

- More persons will be assigned to the site
- Staffing for the three operating shifts can be reduced.

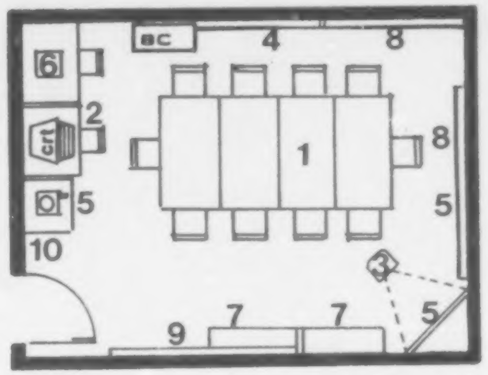
activities	personnel	equipment *
Technical training 1. Observing and evaluating personnel records; conducting personnel interviews to determine training requirements. 2. Developing overall master training plan and presenting special MOS training module program for a specific focus. 3. Studying manuals and other publications. 4. Watching video cassettes, 16-millimeter movies, and slides. 5. Instructing in fire/life/mission safety.	Instructors 1. Commander. 2. NCOIC. 3. Civilian technicians (not an office area for personnel).	Classroom/conference room 1. Table and seating for 12. 2. TV monitor/CRT terminal. 3. Viewgraph projection. 4. Charts and display panels. 5. Audiovisual projection and screens. 6. TEC library monitors. 7. Library of written instructional materials--20 linear feet. 8. Chalkboard. 9. Tackboard for training and information bulletins. 10. Audiovisual equipment storage cabinet. 11. Intercom speaker.
Physical training 1. Involves mandatory military training requirements for physical fitness, weapons qualifications, and CBR training.		Fitness area 1. Exercise equipment: 8 by 4 foot mat, weight set, and exercycle. 2. Exterior area for volleyball and half-court basketball. 3. Athletic and recreational items; balls, bats, horseshoes, etc. 4. Intercom speaker.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
Technical training		
1. Enough space for small groups (up to 20 people) that meet for small training seminars. Space for reading and studying manuals and other publications associated with the training function.	**1.** Provide 25 square feet of space per person. Equipment layout and storage require additional square footage.	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Vinyl asbestos tile. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation from the high noise level generated in the operations area.	**3.** The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum), floor surface at NRC .25 (minimum), and divider partitions (if used) at .85.	**3.** See reference 201, page 3-4, Table 3-2.
4. Flexible lighting.	**4.** Provide adjustable lighting, depending on varied uses. - 20 to 80 footcandles at each work surface. - 10 footcandles at rear of room during audiovisual projection. Surface reflectances should be: - Ceiling: 80 to 90 percent - Walls: 40 to 60 percent - Floor: 20 to 40 percent.	**4.** For further information on quality of lighting design using the ESI concept, see Vol 2, SB2, Electrical--Lighting.
5. Thermal regulation and other comfort features for occupants.	**5.** Regulate temperature at 68^{o}F (heating), 78^{o}F (cooling) with 5 cubic feet per minute per person outside air ventilation rate. Seating should be adjustable to provide maximal body support comfort for many different sizes.	**5.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
6. Electrical power.	**6.** Provide 120/208 electrical service. Provide 120-volt outlets--one receptacle for every 10 linear feet of wall. Specific equipment outlets depend on the room layout.	**6.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
7. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	**7.** Interior finish--Class A or B only. Corridor finish--Class A only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**7.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

requirements	criteria	commentary
Physical training		
1. Enough space to allow each person to perform physical exercises and workouts.	**1.** Minimal area of approximately 150 square feet (10 by 15 feet).	

guidance



11 -- speaker in ceiling

guidance

1. Location

Since most technical training involves hands-on experience with the communications equipment, the training room should be adjacent to the operations space and should have a view into the operations space if possible.

4. Lighting design

Classroom lighting immediately in front of a lecture platform can be controlled from a point convenient to the speaker's platform and also at the entrance. Lighting can be controlled by motor-operated dimmers from the platform and the main entrance to facilitate use of audiovisual aids. Lighting can also be controlled from those points by switches. Minimum lighting shall be provided so that notes can be taken during the use of visual aids.

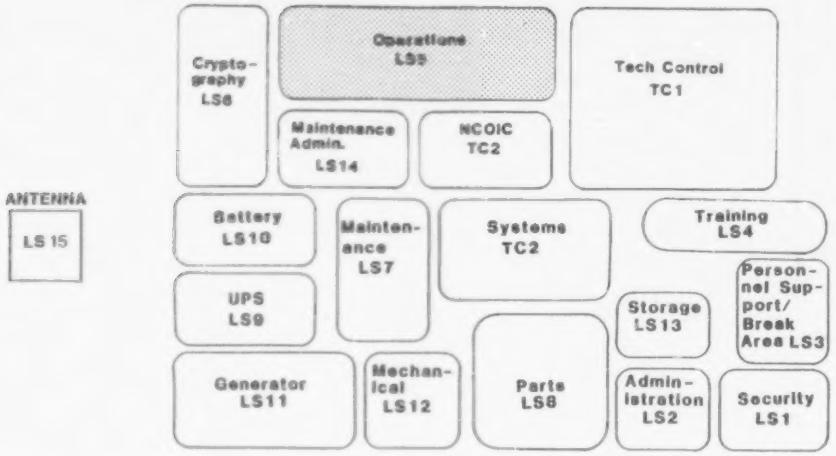
1. Physical training

See "storage" for interior physical training area guidance drawing.

guidance

guidance

OPERATIONS LS5



function

The operations room allowed personnel to operate, maintain, monitor, and repair communications equipment optimally.

policy/sop

1. Equipment and equipment layout should be standardized as much as possible among the facilities comprising a communications system. In determining the layout for facilities in which unencrypted signals bearing classified information are present or processed, the specialized installation guidance found in MIL-HDBK-232(C) must be consulted. Another major consideration is the access necessary for installation, maintenance, and operation. This would include considerations such as providing adequate space between rows of equipment to allow for opening cabinet doors or sliding out modules for maintenance. Another major, but less important, consideration is providing the shortest and most direct waveguide run practical. (2) 5-20

2. Other equipment layout considerations include minimizing interbay cabling runs, providing for future expansion, and providing easy access for maintenance and operational convenience. Sometimes the EM incompatibility of various types of equipment or inadequate ventilation for personnel and equipment can cause problems. Equipment of the same type or with similar function is usually grouped together except when impractical due to size and specific requirements of a station. (2) 5-20

3. Equipment should be grouped properly according to its function and interoperation. Care and thought should be given to the arrangement of meters, test equipment, jackfields, indicating lights, and other such items to insure they are placed approximately at eye level, thus allowing more rapid and convenient use. Equipment should not be mounted at the bottom of a bay if it can be damaged easily or if its size and shape will interfere with power boxes or other hardware at the bottom of the cabinet or rack. Most microwave radio equipment comes fully packaged with all components already mounted in a cabinet or rack. (2) 5-21

4. The station's operational plan must be studied to determine communication circuit requirements when placing each component or rack assembly. In small stations, it is recommended that the equipment be aligned in a row along, one or, if need be, both sides of the building with enough space in between to accommodate a normal floor traffic pattern. However, this type of layout generally will not be suitable in stations for which large quantities of equipment are involved. In the large station, the most practical layout is usually one in which the equipment is aligned in bays across the width of the room, with enough space between bays to permit free access to each rack assembly. (2) 5-22

issues and assumptions

1. Automated record keeping

CRTs with hardline printers can streamline paperwork by storing all circuit history files on disk. This will allow more rapid troubleshooting in-house.

2. Electromagnetic compatibility (2) 5-43

Electromagentic compatibility (EMC) is a complex subject, so that specialists often must perform the type of EMC study needed to insure the equipment or equipment layout produces no interferences or radiation hazard.

DOD is working on new regulations to control permissible levels of EM pollution of the frequency spectrum. This work reflects the concern for environmental protection. Radiation hazards also are being regulated through concern for occupational safety. Engineering agencies working for the Government must therefore know the legal and regulatory aspects of EMC and radiation hazards to meet these requirements.

Military specifications on EMC such as MIL-STD-461, -462, and -463 are intended to control and achieve an acceptable figure of merit or quality in the development of new communications equipment. They do not eliminate the need for EMC engineering in facility design. In addition to equipment quality, the frequency selection, nearness to other facilities and, to some extent, the facility design itself are variables in the interference generation problem. (2) 5-43

3. Determining the correct shielding procedure

A comprehensive approach to the shielding of equipment from radio-frequency interference (RFI) or TEMPEST involves (a) a building layout to optimize inherent facility shielding conditions, (b) suitable location of all electronic equipment and signal cables, and (c) selection of effective shielding materials and construction components.

See Vol 2, SB4, for additional guidance information.

activities

1. Monitoring communication equipment (patch and test).
2. Isolating fault.
3. Doing quality control maintenance tests.
4. Troubleshooting and patching to good equipment.
5. Identifying bad connections.
6. Writing and typing reports.
7. Conducting training sessions.

personnel

1. OPS NCOIC.
2. Two to six operators.

equipment *

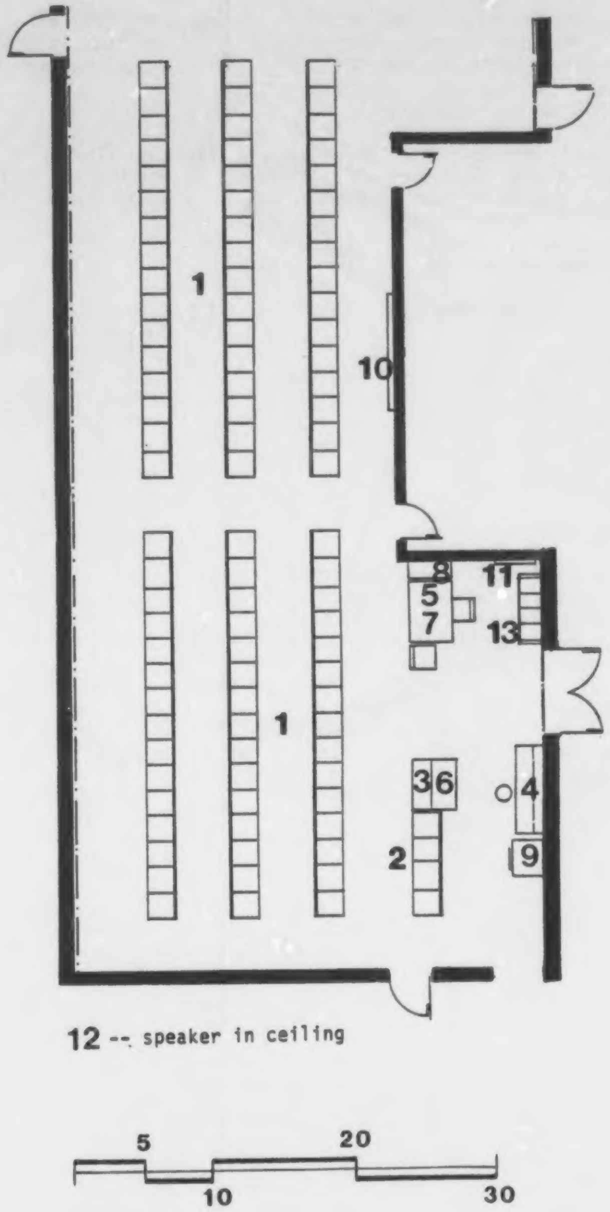
1. Electronic communication system.
2. Patch bays.
3. Control console.
4. Workbench (6 linear feet) with shelving for manuals.
5. Desk with chair.
6. CRT at console.
7. Telephones.
8. Typewriter(s) or word processor(s).
9. Filesafe.
10. Electrical shock first-aid-kit.
11. Alarm panel.
12. Operational voice intercom control.
13. Record file (10 drawers).

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Adequate space for the operation and monitoring of communications-electronics (C-E) equipment. Spatial requirements must allow for proper spacing between equipment to facilitate easy maintenance.	**1.** Varies due to extent of communication equipment designed. See layout in Guidance.	
2. A secure environment for C-E equipment.	**2.** The operations room must be lockable when unstaffed and must be supplied with an intrusion alarm system. The operations console should be fitted with alarms for intrusion, power failure, and generator status. Covers should be provided on overhead rods for rapid sanitizing of applicable equipment.	**2.** See Vol 2, SB7, Security (Zone 3), for more information.
3. Signal shielding.	**3.** See Vol 2, SB4--Grounding, Bonding and Shielding along with SB7--Security Systems for more information.	
4. EMP/HEMP shielding.	**4.** Shielding is necessary for survivability and uninterrupted functioning when the facility is subjected to EM pulse (EMP) and high-altitude EM pulse (HEMP). Protective measures are based on intercepting the incident energy and dissipating it or reflecting it away from the threatened device, equipment, or facility.	**4.** See Vol 2, SB5, EMP/HEMP Protection, for more information.
5. Raised floor system.	**5.** Raised or false floors are necessary for proper cooling of the equipment.	**5.** See also Vol 2, SB2, Communication Station Buildings--Architectural.
6. Interior finishes suitable for durability, maintenance, and room function.	**6.** Floor--Vinyl asbestos tile panels. A raised floor system shall be used over a concrete floor with a dust-on finish that contains a hardener. See Vol 2, SB2--Interior Construction. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Wall--Paint over concrete, gypsum board, or plaster and acoustic tiles to within 4 feet of the floor. Ceiling--Acoustic tile.	**6.** See also Vol 2, SB2, Interior Construction and Finishes.
7. Acoustical isolation attenuation for variable noise levels produced by electronic equipment.	**7.** Adjacent room walls should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum) and floor surface at NRC .25 (minimum). Acoustic tile is also required to within 4 feet of the floor.	

requirements	criteria	commentary
9. Controlled environment for proper operation.	**9.** Maintain 70°F (±2°) and 50 percent relative humidity (± 5 percent continuously. Provide 5 cubic feet per minute per person outside air ventilation rate or the outside air quantity necessary to maintain a room pressurization requirement of .05 to .10 water gage.	**9.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
10. Electrical power.	**10.** Provide 120/208 electrical service and 120-volt outlets--one receptacle for every 10 linear feet of wall. Outlets for equipment should be available under the raised floor as per layout. Electrical power must fall within the 10,000 to 500,000 watt range, with frequency levels at 50 to 60 hertz ± 5 percent.	**10.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
11. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	**11.** Vaulted enclosure walls--2 hour (minimum) fire-rated, shielded construction. Interior doors in vaulted walls--1.5-hour fire-rated doors; shielded doors and frames. Interior finish--Class A or B only. Automatic fire detection--Local alarm. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility. Manual emergency equipment power shut-off at exits. Under raised floor area--Automatic fire detection: Local alarm. Automatic Halon 1301 suppression system if required for cross-zoned or matrix detection. Sprinkler and Halon systems are not normally installed in the same areas.	**11.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information. Automatic fire suppression may include Halon 1301 where specifically justified

guidance



12 -- speaker in ceiling

guidance

1. Equipment expansion

It is advisable to arrange equipment in the equipment room such that future expansion of the building will not necessitate complete rearrangement. (2) 5-21

Approximately 3 feet of clearance space, as a minimum, should be allowed in front of and to the rear of an equipment bay. If a bay does not permit rear access to equipment, the bay can be installed with no clearance on the back side, that is, against a wall or back-to-back with other bays, unless ventilation requirements are compromised. (2) 5-21

5. Raised floor system

Most equipment that requires significant cooling to maintain communication operations should be located on raised floors for maximal use of coupled air directly through the cabinets. Cooling air at 60°F supplied directly into the base of the transmitters will leave the top at approximately 72°F. Thus, when the air exits the equipment, it is at a more comfortable temperature for persons working in the space.

8. Control area

Light fixtures should provide an approximate uniform lighting intensity of 70 footcandles and should be equipped with light control lenses or specular parabolic louvers to minimize glare on working surfaces. Lights over the area in which the control console is located shall be provided with wide-range (100:1) dimming control. (23)12

Equipment area

Fixtures should be arranged above the operating aisles and should run parallel to equipment row arrangement. They should be located so the light does not cast shadows or reflections on the front of the technical equipment and so light is not obstructed by the cable trays. Flush-mounted fluorescent lighting fixtures are recommended, and they shall be equipped with integral RFI filters (GE no. 89G635, Sprague IF-37, or equivalent). The lights shall not interfere with access to the cable trays or equipment. (23)12 Portable task lighting should also be supplied for the equipment area at 70 to 100 footcandles.

9. Protection from moisture migration

Operating spaces that contain electronic equipment usually require close temperature and humidity control. Vapor barriers placed under floor slabs and roofing usually prevent moisture migration into and out of interior electronic equipment spaces. Additional protection must be provided if exterior walls form part of the equipment space. (92)12.1-13

See also Vol 2, SB2, Special Mechanical.

best copy available

guidance

Mechanical

The recommended operating temperatures and humidity conditions should be obtained from the manufacturers of the communications and data processing equipment and should be used in designing the environmental control system.

Air-conditioning

Continuous, reliable operation of any computer system depends on an efficient, well designed, properly controlled air-conditioning system. Inadequate cooling contributes as much to failure as poorly regulated power. (74) 4-17

Even though certain individual units can operate outside the limits of the overall specifications, overall environmental requirements are dictated by the most restrictive unit of the system. The computer system's requirements are the major considerations; however, good design will also consider personnel comfort. (74) 4-17

An air-conditioning system for a computer installation differs from ordinary comfort air-conditioning in the following ways. (74) 4-17

- Heat dissipation by computers is relatively constant; therefore, cooling is required year-round.
- The computer room sensible heat ratio is near unity because heat dissipated by the computer system is all sensible.
- Above-average air filtration is required to prevent errors caused by dust particles on magnetic tapes.
- The number of air changes per hour varies between 30 and 60 because of the computer equipment's high heat dissipation.
- Humidity control is required year-round to maintain necessary conditions in the computer room. However, introducing water vapor into the airstream for humidification is not recommended for electronic equipment areas because water vapor can damage electronic components. (40) 7-3

Temperature and humidity recording instruments

Recording instruments are needed to provide a continuous record of temperature and humidity in the machine area. Also, if the air-conditioning requirements are not met, a record must be available to indicate the extent and duration of the undesirable condition and indicate whether a drying-out period is required. In some cases, this may save machine shutdown time. (74) 4-25

The record of temperature and humidity can be used to: (74) 4-25

guidance

- Insure the air-conditioning system continues to perform its job properly. Installation errors and loss of efficiency due to malfunction of some air-conditioning system part can be detected quickly.
- Determine if a mandatory drying-out period is needed when humidity limitations are exceeded. Drying out may be necessary if the excess humidity occurs either during periods of actual operation or while the machine is shut down and unattended. The extent and duration of excessive humidity determines the length of the drying-out period.
- Determine if the environment meets requirements for the machine.

A visual or audible signaling device is desirable in the recording instrument. This is to provide visual or audible indication that temperature or humidity in the computer area is nearing the maximum limit.

Direct-reading instruments with a 7-day electric-drive chart are sometimes used in installations to monitor ambient room conditions. The recorder is usually located at a representative spot in the room and adjacent to the control devices.

For monitoring underfloor air conditions, a remote indicating instrument is recommended. This is usually a 7-day electric-drive chart and can be the wet-and-dry-bulb or electronic type if direct reading is not available. The recording instrument can be located on the wall in the operations room, in the mechanical equipment room, or in any other location convenient to the building engineer.

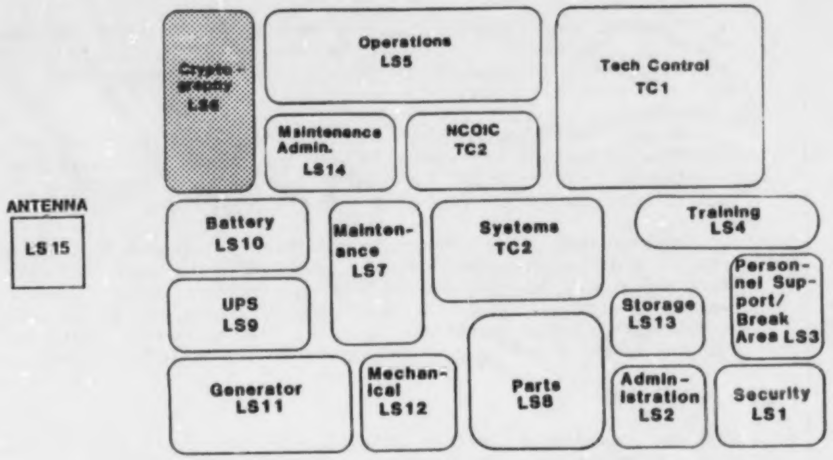
10. Electrical

Consider providing a flexible system that will meet the facility's future requirements. Electronic equipment is constantly being upgraded, modified, and replaced. Bus duct systems and cable trays may prove to be most flexible for areas in which new equipment is expected or that may have frequent modification. (5) 3-4-8. A recommended expansion capacity of 40 percent is usually provided.

Specifically refer to the "Electrical" portion of "Issues and Assumptions" portion of SB2, Vol. 2, for information relative to host nation power requirements. Additional information may be found in "guidance" of SB2 with respect to the standard frequencies and voltage levels used by various nations.

Provide host nation standard outlets if applicable.

CRYPTOGRAPHY LS6


Crypto-graphy LS6
Operations LS5
Tech Control TC1
Maintenance Admin. LS14
NCOIC TC2
ANTENNA
LS 15
Battery LS10
Mainten-ance LS7
Systems TC2
Training LS4
UPS LS9
Storage LS13
Person-nel Sup-port/ Break Area LS3
Generator LS11
Mechan-ical LS12
Parts LS8
Admin-istration LS2
Security LS1

function

The cryptography area provides a secure place for encryption or decryption of information that passes through the communication facility.

policy/sop

1. The national policy objective is to insure that national security information is not lost through unintentional emanations. To achieve this, equipment should be designed to meet TEMPEST requirements and should be tested to verify compliance with TEMPEST specifications. See Vol 2, SB4, for additional guidance information.

2. The RED/BLACK concept is the basis for the facility criteria development presented here. The RED/BLACK concept dictates that electrical and electronic circuits, components, equipment, systems, and other items that handle national security plain language information in electrical signal form (RED) be separated from those handling encrypted or unclassified information (BLACK). Under this concept, RED and BLACK terminology is used to clarify specific criteria relating to the difference between such circuits, components, equipment, and systems, and the area in which they are contained.

issues and assumptions

1. Proper location for cryptographic equipment

Locate sensitive and critical equipment as close to the core of the structure as operational requirements permit. In addition, identify the location of likely sources of interference such as power substations, engine-generators, and RF transmitters; maximize the separation between such sources and potentially susceptible equipment or systems. (15b) 1-173

2. Electromagnetic compatibility (2) 5-43

Electromagnetic compatibility (EMC) is a complex subject so that specialists often are needed to perform the type of EMC study needed to insure that the equipment or equipment layout produces no interference or radiation hazard.

DOD is working on new regulations to control permissible levels of EM pollution of the frequency spectrum. This work reflects the concern for environmental protection. Radiation hazards also are being regulated through concern for occupational safety. Engineering agencies working for the military must therefore know the legal and regulatory aspects of the EMC and radiation hazards to meet these requirements.

Military specifications on EMC such as MIL-STD-461, -462, and -463 are intended to control and achieve an acceptable figure of merit or quality in the development of new communications equipment. They do not eliminate the need for EMC engineering in facility design. In addition to equipment quality, the frequency selection, nearness to other facilities, and, to some extent, the facility design itself are variables in the interference generation problem. (2) 5-43

3. Correct shielding procedure

A comprehensive approach to shielding equipment from radiofrequency interference (RFI) or TEMPEST involves (a) a building layout to optimize inherent facility shielding conditions, (b) suitable location of all electronic equipment and signal cables, and (c) selection of effective shielding materials and construction components. See Vol 2, SB4, for additional guidance information.

activities

1. Inspecting and diagnosing equipment and parts.
2. Doing complete preventive and unscheduled maintenance.
3. Assembling electronics.
4. Testing electronics.
5. Insuring secure storage of parts and equipment.
6. Maintaining records on parts and equipment.
7. Writing and typing reports: 349s, and equipment historical records.
8. Monitoring CRYPTO sync panel.
9. Notifying contractor on CRYPTO when problems arise.

personnel

1. Two crypto technicians.

equipment *

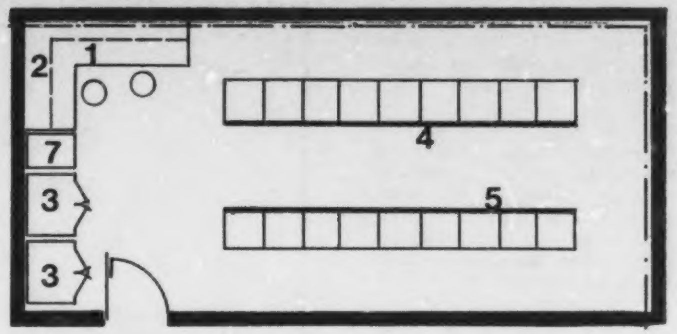
1. Two electronic workbenches with stools.
2. Shelving over workbench for publications manuals.
3. Locked storage cabinets secured to wall for special electronic equipment.
4. Red Patch Bay.
5. Black Patch Bay.
6. Telephone.
7. Filesafe (1) for records.
8. Intercom speaker.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Adequate space to accommodate the cryptologic function.	**1.** Approximately 1000 square feet are required to provide space for two personnel and the required cryptography equipment.	
2. Security.	**2.** It must be lockable when unstaffed by providing a cipher lock and intrusion alarm system. In addition to physical protection by walls and doors, the ceiling and air-conditioning ducts must be intrusion-proof. For RED/BLACK security, the installation shall conform to MIL-HDBK-232.	**2.** See Vol 2, SB7, Security (Zone 3), for more information.
3. Communication lines for emergency operations.	**3.** The telephone system must be coordinated with key lines (pre-designated personnel).	
4. RFI/TEMPEST shielding.	**4.** Shielding is required for electrical and electronic equipment to prevent it from propagating interference and to protect it against interference propagated by other electronic devices (15a)[7] The term "TEMPEST" flags the system as one processing National Security related information and establishes the need for additional, site-specific alterations and improvements to the facility.	**4.** See Vol 2, SB4, Grounding, Bonding and Shielding, along with SB7, Security Systems, for more information.
5. EMP/HEMP shielding.	**5.** Shielding is necessary for survivability and uninterrupted functioning when the facility is subjected to EMP and HEMP. Protective measures are based on intercepting the incident energy and dissipating it or reflecting it away from the threatened device, equipment, or facility.	**5.** See Vol 2, SB5, EMP/HEMP Protection, for more information.
6. Interior finishes suitable for durability, maintenance, and room function.	**6.** Floor--Vinyl asbestos tile panels. A raised floor system shall be used over a concrete floor with a dust-on finish that contains a hardener. See Vol 2, SB2, Interior Construction. Base--Glazed structural units, rubber vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster and acoustic tiles to within 4 feet of the floor. Ceiling--Acoustic tile.	**6.** See also Vol 2, SB2, Interior Construction and Finishes.

requirements	criteria	commentary
7. Acoustical isolation/attenuation to provide comfort for a nondisruptive environment.	**7.** The walls surrounding the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .90, floor surface at NRC .50.	
8. Adequate lighting.	**8.** Light fixtures should provide an approximate uniform light intensity of 70 footcandles and should be equipped with light control lenses or specular parabolic louvers to minimize glare on working surfaces. Fixtures shall also be equipped with integral RF interference filters (GE no. 89G635, Sprague IF-37, or equivalent). The work area shall also be equipped with adjustable task lighting.	
9. Thermal comfort.	**9.** Temperature should be kept at 68°F (heating) and 78°F (cooling). A 5-cubic feet per minute per person outside air ventilation rate should be maintained.	**9.** See also Vol 2, SB2, Communication Station Buildings--Mechanical
10. Electrical power.	**10.** Power should be supplied by a 120/208 electrical service. A 120-volt receptacle should be installed for each workstation at a convenient height and/or for every 10 linear feet of wall. Electrical power must fall within the 10,000- to 500,000-watt range. Frequency levels must be at 50 to 60 hertz ± 5 percent. Provide line filters for RFI on all electrical power lines.	**10.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
11. Fire protection/life safety criteria are based on the assumption that this facility houses critical equipment and data, which creates a severe strategic fire loss potential.	**11.** Vaulted enclosure walls--2-hour minimum fire-rated construction; shielded construction. Interior doors in vaulted walls--1.5-hour fire-rated doors; shielded doors and frames. Interior finish--Class A or B only. Automatic fire detection--Local alarm. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or to constantly staffed station outside the facility. Manual emergency equipment power shut-off at exits. Under raised floor area automatic fire detection--Local alarm; automatic Halon 1301 suppression system if cross-zoned or matrix detection is required. Sprinkler and Halon systems are not normally installed in the same areas.	**11.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information. Automatic fire suppression may include Halon 1301 where specifically justified

guidance



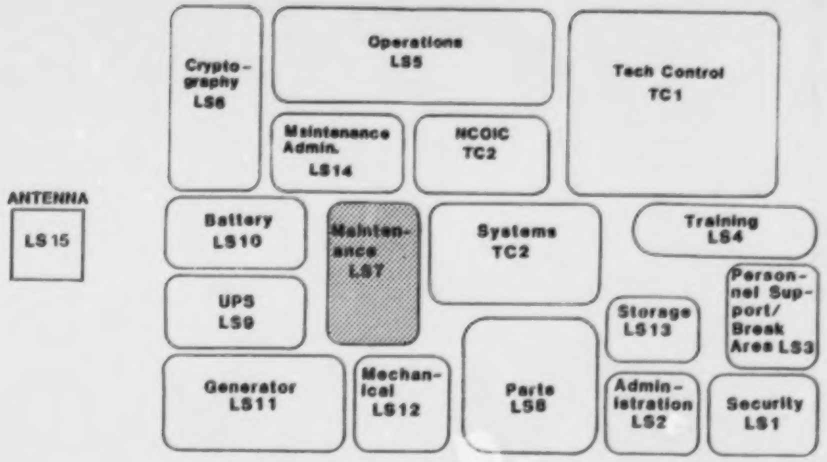
8 -- speaker in ceiling

guidance

guidance

guidance

MAINTENANCE LS7


ANTENNA
LS 15
Cryptography LS6
Operations LS5
Tech Control TC1
Maintenance Admin. LS14
NCOIC TC2
Battery LS10
Maintenance LS7
Systems TC2
Training LS4
UPS LS9
Storage LS13
Personnel Support/ Break Area LS3
Generator LS11
Mechanical LS12
Parts LS8
Administration LS2
Security LS1

function

This area is for assigned personnel and the shift supervisor who repair, clean, and test communication equipment.

policy/sop

1. It is desirable to provide a separate maintenance room with space for repair activities and the associated test equipment and tools. The space required will, of course, depend on the amount of C-E equipment installed, the number of maintenance personnel involved, and requirements for stocking spare parts.

2. To test and service a microwave communications system properly, maintenance personnel should have a thorough understanding of the equipment's physical makeup, operational characteristics, capabilities, and limitations, and should be familiar with the circuit theory of operation. It is equally important that the proper test equipment be available to these personnel. As the area of maintenance progresses from onsite field maintenance to depot maintenance, the quantity and requirements of the associated test equipment will increase, necessitating improved facility responsiveness. (70) 7-51

issues and assumptions

activities

1. Inspecting and diagnosing equipment and parts.
2. Completing preventive and unscheduled maintenance.
3. Assembling electronics.
4. Testing electronics.
5. Securing storage of parts and equipment.
6. Maintaining records on parts and equipment.
7. Writing and typing reports, PMI 349's, and equipment historical records.

personnel

1. Shift supervisor.
2. One or two specialists.

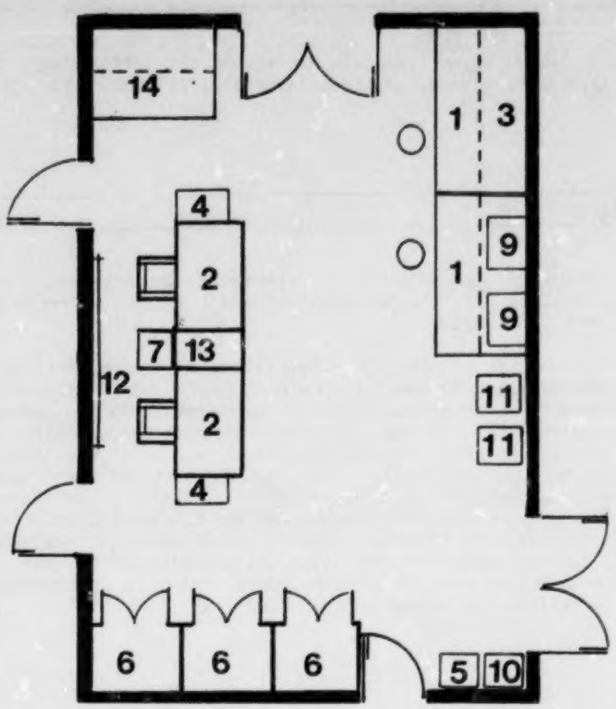
equipment*

1. Two electronic workbenches with stools.
2. Two desks with chairs, one with a typing stand.
3. Shelving over workbench for publications.
4. File cabinet.
5. Portable vacuum cleaner to clean equipment parts. If compressed air blower unit is supplied instead, use 30 pounds per square inch maximum to prevent damage to parts. (Use with a dust collector.)
6. Locked storage cabinets secured to wall for special electronic equipment.
7. Typewriter or word processor.
8. Intercom speaker.
9. Wall-mounted test equipment over workbench.
10. Portable power supply test set.
11. Two scope carts.
12. Multiboard (24 by 48 inches).
13. Telephone.
14. Shelving for inactive equipment storage.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for inspection, disassembly, and reassembly of sensitive electronic equipment. Space must also accommodate administrative, tool, and part needs.	1. Provide approximately 500 square feet.	
2. A secure, controlled area.	2. The room should be lockable when unstaffed.	2. See Vol 2, SB7, Security (Zone 3) for more information.
3. Interior finishes suitable for durability, maintenance, and room function.	3. Floor--Vinyl asbestos tile. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	3. See also Vol 2, SB2, Interior Construction and Finishes.
4. Acoustical isolation and attenuation to eliminate C-E equipment noise to help personnel concentrate when they work on electronic components.	4. The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC. 90, floor surface at NRC .50, and divider partitions (if used) at .85.	
5. Adequate lighting.	5. Fixtures should provide 70 footcandles for ambient lighting and 150 footcandles for task lighting.	5. For further information on quality of lighting design using the ESI concept, see Vol 2, SB2, Electrical Lighting.
6. Thermal regulation and other comfort features for occupants.	6. Regulate temperature at 68°F (heating), 78°F (cooling), with a 5-cubic feet per minute per person outside air ventilation rate. Provide a chair with seat height adustment, casters, swivel, and independent backrest adjustment.	6. See Also Vol 2, SB2, Communication Station Buildings--Mechanical.
7. Electrical power.	7. Install 120/208 electrical service. 120-volt receptacles should be located for convenience at all workstations and workbenches at the appropriate height for every 10 linear feet of wall. Provide four duplex outlets at each workbench. All equipment and workbenches must be grounded. Frequency levels should be 50 to 60 hertz $\pm$ 5 percent.	7. See also Vol 2, SB2, Communication Station Buildings--Electrical.
8. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	8. Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	8. See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance


14
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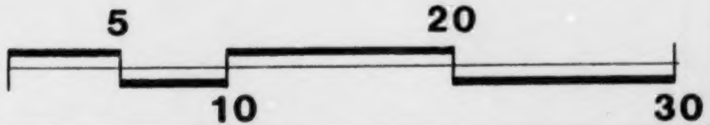
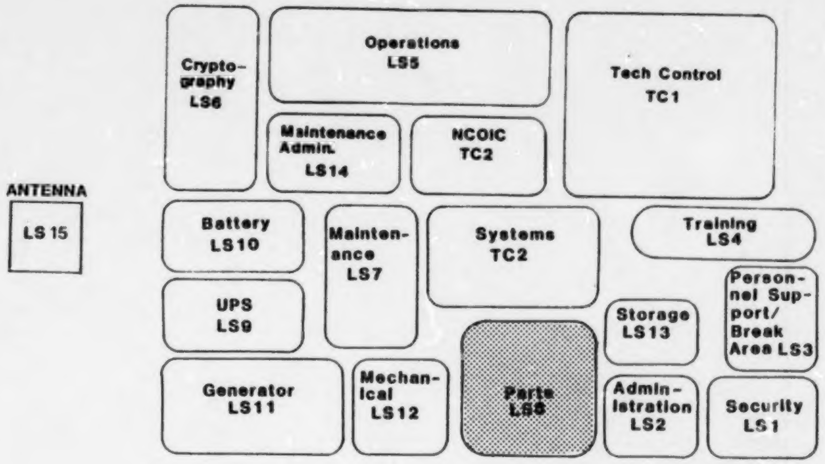
8 -- speaker in ceiling



guidance

PARTS LS8


ANTENNA
LS 15
Crypto-graphy LS6
Operations LS5
Tech Control TC1
Maintenance Admin. LS14
NCOIC TC2
Battery LS10
Mainten-ance LS7
Systems TC2
Training LS4
UPS LS9
Storage LS13
Person-nel Sup-port/ Break Area LS3
Generator LS11
Mechan-ical LS12
Parts LS8
Admin-istration LS2
Security LS1

function

This element is the space required to manage all parts supply operations: ordering, receiving, storage, inventory, and security.

policy/sop

1. Requirements for spare parts storage space are determined by the type of equipment at the installation and the level of maintenance to be performed onsite.

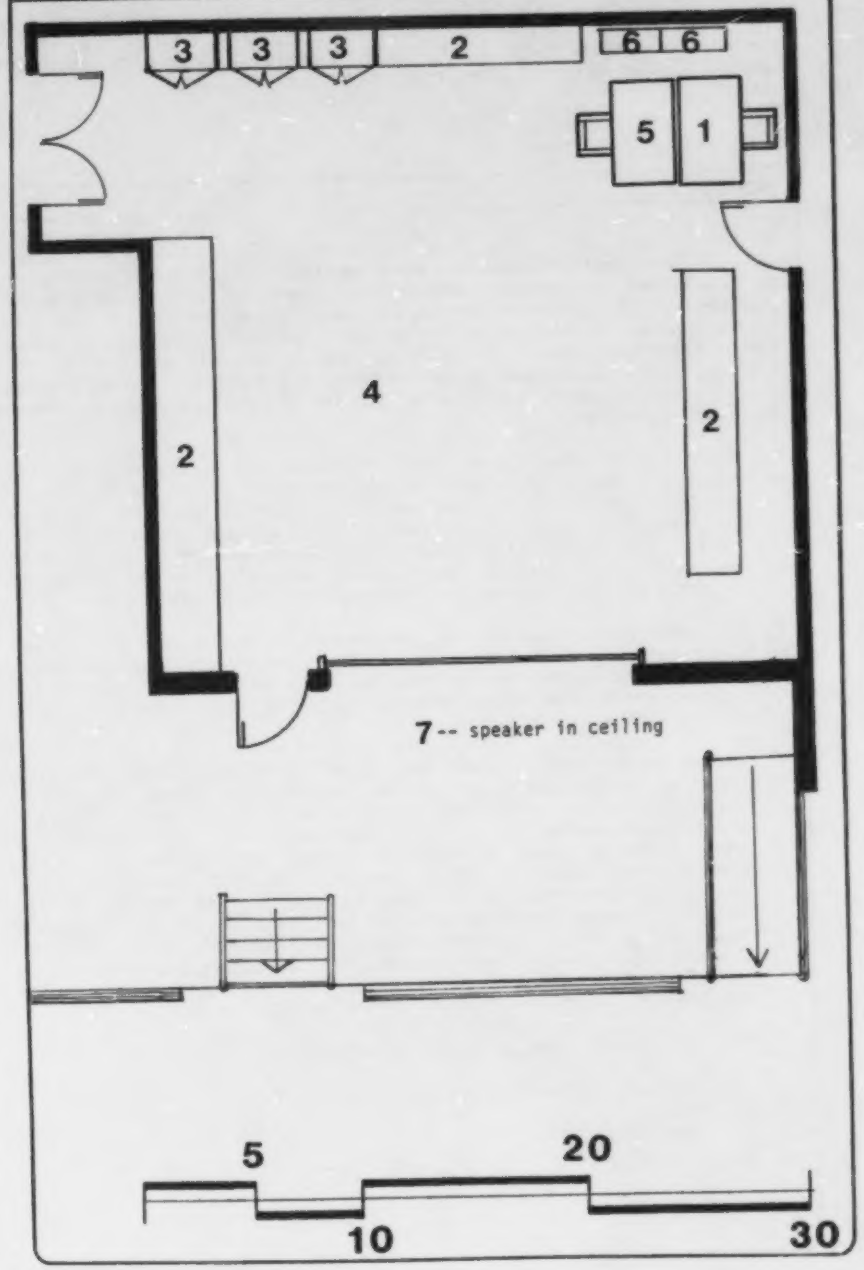
2. During preventive maintenance inspections, it may be noticed that some components' performance has deteriorated. Rather than wait for the component to become weaker or to fail completely and cause system interruption, it is considered good maintenance practice to replace the faulty parts during the inspection. Although components would be replaced before their full service life has been realized, service interruptions could be avoided. This practice would, in turn, increase the expected replacement parts cost for an operating system; however, the increase would be justified on the basis of increased system reliability and savings for additional manpower costs that would be incurred in making special trips to unattended stations to restore system operation. (70) 7-49

issues and assumptions	activities	personnel	equipment*
	1. Developing parts order lists and working with station Central Supply Office. 2. Receiving, unpacking, shelving of prescribed load list and facility supply parts. 3. Packing and shipping repairable items.	1. One supply specialist.	**1.** Table (30 by 60 inches) with chair. **2.** Shelving--30 linear feet, floor-to-ceiling type. **3.** Three locked cabinets (24 by 36 inches). **4.** Open area (100 square feet) for unpacking orders. **5.** Desk with chair for parts ordering, microfiche unit. **6.** Bookcase for supply manuals--3 to 4 linear feet. **7.** Intercom speaker.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for ordering, receiving, and storing C-E equipment. Space must include an open area to facilitate easy receiving of large equipment and supply orders.	**1.** Provide approximately 1000 square feet to accommodate storage shelves and to leave an open area for receiving shipments of parts and supplies.	
2. A secure environment.	**2.** This area must be lockable when unstaffed. Provide an intrusion alarm system.	**2.** See Vol 2, SB7, Security (Zone 3), for more information.
3. Interior finishes suitable for durability, maintenance, and room function.	**3.** Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	**3.** See also Vol 2, SB2, Interior Construction and Finishes.
4. Acoustical isolation and attenuation: Acoustical comfort for a nondisruptive environment.	**4.** Adjacent room walls should limit sound transmission to 40 decibels.	
5. Adequate lighting.	**5.** Lighting should be: 20 footcandles (ambient) and 70 footcandles (task).	
6. Environmental control for proper storage of electronic equipment.	**6.** Regulate temperature at 68°F (heating), 78°F (cooling), with a 5-cubic feet per minute per person outside air ventilation rate.	**6.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
7. Electrical power.	**7.** Supply 120/208 electrical service. 120-volt receptacles should be located for convenience at all workstations and workbenches at the appropriate height and for every 10 linear feet of wall. Required frequency levels are 50 to 60 hertz ± 5 percent.	**7.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
8. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	**8.** Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**8.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



guidance

1. Location

Locate the parts area between the exterior receiving dock and the maintenance room.

Provide an open area for unpacking equipment before it is moved into operation or equipment rooms.

A loading dock should be designed for a minimum load of 250 pounds per square foot and should provide enough room to maneuver equipment.

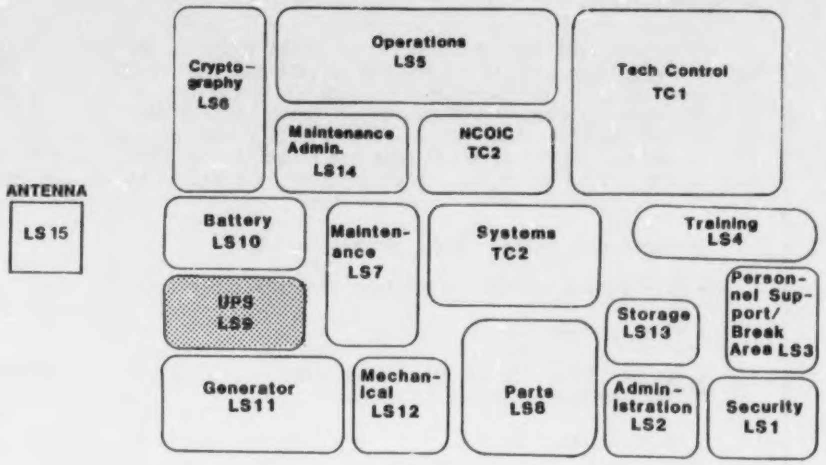
2. Door security

Maintenance/utility doors not permitting entry to administrative/operational spaces should be secured with heavy cylindrical case lock and latch sets in conformance with Federal Specification FF-H-106 and with Builders Hardware Manufacturers Association Standard 601. Doors and hatches that are externally accessible and lead to critical utilities should be secured with padlocks and hasps in conformance with Military Specification MIL-P-43607 instead of or in addition to the cylindrical case or bored locksets specified above. (5) 3-5-9

The hardware set for secure doors should be:

- 1/8-inch-thick drill-resistant hard plate for inside of door
- Secured-type hinges
- Cypher lock with an electronic access control, electric strike, and emergency battery standby
- Combination lock
- Door closer (on each leaf if pair door is required)
- Wide-angle peephole
- Foot bolts and pull-chain bolt for inactive leaf of pair doors.

UPS LS9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Training LS4
UPS LS9
Person-nel Sup-port/ Break Area LS3
Storage LS13
Generator LS11
Mechan-ical LS12
Parts LS8
Admin-istration LS2
Security LS1

function

An uninterruptible power supply (UPS) is designed to provide continuous power, without delay or transients, to the critical load.

policy/sop

UPS are characterized by their ability to condition primary or auxiliary power to precise, high-quality power as required by the C-E equipment. UPS maintain continuous power during periods of transfer from one power source to another or for a period long enough to allow for an orderly shutdown. A UPS is required to maintain and provide continuous, conditioned power to the critical C-E equipment and to provide protection from power line transients. The UPS must have the following specific properties.

1. A UPS should serve the critical technical load. It should be solid state with batteries capable of supporting 125 percent of the critical technical load for a minimum of 15 minutes. The UPS is designed to protect equipment from disturbances of voltage and frequency inherent with conventional power distribution systems. The UPS must maintain output voltage and frequency regardless of the nature or severity of the incoming line fluctuations and/or changes in load.

2. The UPS should operate in conjunction with the existing power distribution system to provide quality power for critical technical loads. The system should consist of a solid-state inverter, a battery charger/rectifier, storage batteries, and a static transfer switch with a bypass switch.

3. During normal station operation, the UPS will be supplied with a.c. power by the primary power source; the UPS then changes a.c. power into storable d.c. electrical energy to be used as a short-term, no-break power supply for critical equipment. The UPS uses only a small amount of energy to maintain storage levels. The rest is reconverted into a.c. electrical energy. The UPS' a.c. power input and output are isolated from each other by the energy storage medium. A means should be provided to bypass the UPS completely in the event of failure or maintenance. (1)150 UPS electronic components should be in a room separate from machinery and batteries to prevent their vibration, pollution, overheating, and corrosion. See MIL-HDBK-411A for air-conditioning criteria.

   The four common types of installed UPS are:

   a. Flywheel--motor-generator.
   b. Rotary.
   c. Electronic.
   d. Hybrid.

policy/sop

4. The power sources and distribution system should be dependable, free from disturbances, and easily maintained. Efficient operation of the earth complex requires a dependable power system that minimizes the number and length of communication outages. Added to the primary objective of dependability are: (a) cost effectiveness to provide the best possible system for the least amount of money and (b) standardization to aid in cost effectiveness, maintainability, and ease of support. Additional information is available in MIL-HDBK 411A AR 420-43, NAVFAC DM-4, NAVFAC DM12.1, AFM 88-15, and the National Electrical Code. (1) 30

5. A modern solid-state UPS is a reliable source of conditioned power. The UPS usually is provided with an electronically controlled static bypass switch when input and output frequencies are identical. The static switch permits automatic bypass if the UPS fails. Also, a manual bypass switch is often provided to permit maintenance on any part of the UPS system. (1) 153 Solid-state UPS have many advantages over mechanical rotary UPS. Bearing, vibration, and low efficiency problems are avoided, and single-point failures are minimized by selection and proper configuration of solid-state UPS. Reserve battery capacity of 15 minutes is normally enough for bringing the UPS online, at which time the auxiliary power plant should be providing the input power. (19) 17

See Vol 2, SB2, for detailed information on UPS.

issues and assumptions

1. Selection of UPS

Single UPS--The single, static UPS has the advantage of simplicity and low cost. The single UPS configuration consists of a rectifier, an inverter, associated controls, protective devices, and an energy storage battery. This system also includes a static bypass circuit that automatically transfers the critical load to the alternate power source without an interruption to the load. When an inverter output failure is sensed, the critical load is transferred to the bypass circuit in less than 5 milliseconds. The synchronous bypass adds about 20 percent to the cost and provides eight to ten times more reliability. UPS failure causes the static switch to transfer the load to the input source, keeping the load online. When selecting this configuration, two conditions must be considered for successful operation: (a) the transfer must be fast enough that the load will not be disconnected and (b) the frequencies and voltages of the primary power and the inverter output must be the same.

Parallel redundant system--This system consists of at least two UPS operating in a load-sharing mode. The output of each is normally connected to the bus through a static interrupter for protection. If an internal fault occurs within an inverter of either system, the static interrupter isolates that inverter from the bus. In case of a bus fault, the interrupter operates in a current limiting mode until the output circuit breaker trips. Parallel UPS may be configured for various combinations of units operating in parallel, such as three units on-line with any two capable of serving the load. Parallel configuration is recommended when the frequency of the primary electric power supply must be converted to serve the critical load such as 50 to 60 hertz.

"Cold" standby independent UPS--This configuration consists of two independent UPS with a common battery. One UPS is online and the other is in "cold" standby. Both UPS are equipped with static bypass circuits that, in the event of UPS failure, automatically transfer the critical load to the primary or auxiliary power source without interruption. The second UPS is then energized manually and placed in the bypass mode and the critical load is assumed by the transfer action of the static switch. The two UPS are not intended to operate in parallel and interlock circuits are provided on the UPS output.

issues and assumptions

2. Float battery systems versus solid-state UPS

The float battery system is the most economical and reliable method of providing continuous d.c. power to critical loads. Since this system is inherently very reliable and since future power sources (renewable energy) provide d.c. power, long-range communications plans call for increased use of d.c.-powered electronics. (19) 10

Floating battery power should be designed for optimal reliability and maximal independence of primary power abnormalities. The battery should be sized to furnish full power to the critical technical load for a period consistent with requirements and system design for auxiliary power capabilities. The battery system supporting solid-state UPS should be sized for 15 minutes in most cases. For 48-volt applications, if specific battery operation requirements are not available, the batteries should be sized for 4-hour operation at attended sites and a minimum of 8 hours' operation at unattended sites. A single float battery system should be designed for all float battery requirements in a common facility. A minimum of two rectifier chargers should be provided. The total number of rectifiers required will be determined by the number needed to supply the load and battery charging current, plus one or more for the maintenance space. When operating on commercial power, the rectifiers should be sized to provide a battery recharge-to-discharge time ratio of not more than 30 to 1. When static inverters are used, provisions should be made to transfer the load gradually from the battery to the primary or auxiliary power source. This provision, normally handled by the rectifier, will minimize transient conditions on the primary or auxiliary power source during the transfer period. (19) 22

activities

1. Doing prescribed maintenance and inspection (PMI) work.
2. Conducting operational checks and load tests.

personnel

1. One, though not located in room continuously.

equipment*

1. Solid-state rectifier/charger.

2. Batteries.

3. Inverter, synchronizing equipment.

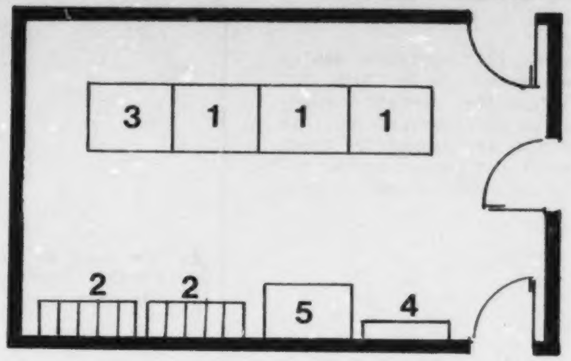
4. Static switches.

5. Rotary converter (if 60-hertz equipment is used in a 50-hertz host country.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for the operation and monitoring of UPS equipment; proper spacing between equipment for easy maintenance.	**1.** Space needs vary with the communication equipment design (i.e., power requirements), but an average is 400 to 500 square feet. Depending on UPS capacity, certain components are very large and heavy, so consideration must be given to installation and repair or replacement of those items. To accommodate this, knock-out panels may be required. Cable ducts should be located for easy access and drainage.	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation and attenuation for variable noise levels produced by electronic equipment.	**3.** Adjacent room walls should limit sound transmission to 40 decibels.	
4. Adequate lighting.	Provide 20-footcandle (ambient) fluorescent fixtures and 70 footcandles (task) for testing and inspection.	
5. Environmental control for proper operation of electronic equipment.	**5.** Regulate temperature at 50°F for heating. Cooling temperature must be less than 90°F for all solid-state UPS equipment.	**5.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
6. Electrical power.	**6.** Commercial electrical service used in the building will be site-specific. Availability depends on the host country if OCONUS. An outdoor transformer can be installed for UPS spaces in terms of the communication equipment and switchgear. Provide 120-volt receptacles as needed.	**6.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
7. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**7.** Interior enclosure walls--1-hour fire-rated construction. Interior doors--20-minute fire-rated doors. Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**7.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



guidance

1. Location

The UPS and associated battery should be installed in separate rooms. Construction should be permanent type and the wall separating the UPS should be fire-rated (See Vol 2, SB3). Power continuity during emergency periods of power transfer is maintained by an energy storage battery. Reserve battery capacity of 15 minutes normally is enough for bringing the UPS online, during which time the auxiliary power should be providing the input power.

Structural--Minimum floor load is 250 pounds per square foot. A clear ceiling height of 10 feet should be provided.

Doors--All doors to the UPS room should be constructed of steel and should have a minimum dimension of 4.0 by 7.0 feet. Consider installing a louvered bottom door panel on the interior door(s).

5. Environmental control

Consider installing a solid-state UPS in an environmentally controlled room if adverse environmental conditions exist or if recommended by the UPS manufacturer.

guidance

Figures LS-1 and LS-2 show the preferred method of heating and ventilating UPS equipment areas, as well as providing the required ventilation system redundancy. The canopy hood, also called a "receiving hood," should be slightly larger than the equipment or exhaust grills in the cabinets and should extend fairly close to them. Direct connections should be avoided unless specifically recommended by the equipment manufacturer. Each exhaust fan should be sized to handle all the air exhausted through the cabinets plus 10 percent (room air) to insure good capture. (5) 3-3-13.

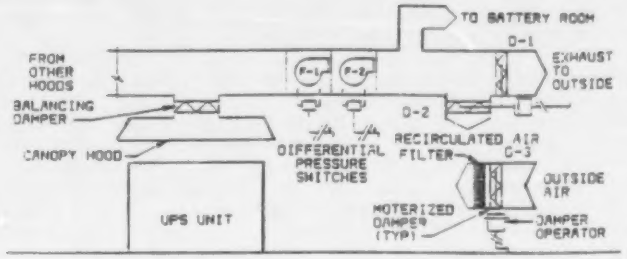

TO BATTERY ROOM
D-1
EXHAUST TO OUTSIDE
FROM OTHER HOODS
F-1
F-2
BALANCING DAMPER
D-2
CANOPY HOOD
DIFFERENTIAL PRESSURE SWITCHES
RECIRCULATED AIR
FILTER
D-3
OUTSIDE AIR
UPS UNIT
MOTERIZED DAMPER (TYP)
DAMPER OPERATOR

FIGURE LS-1. SERIES FAN ARRANGEMENT. (5) 3-3-14

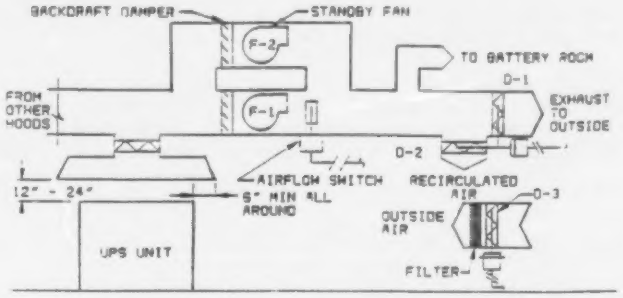
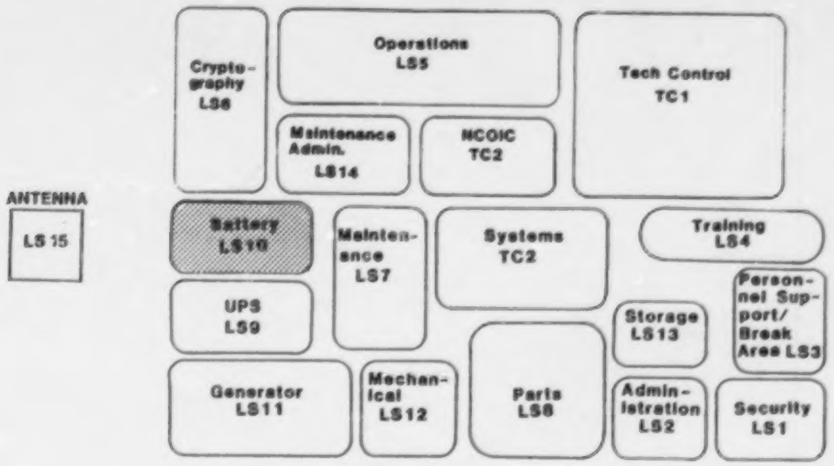

BACKDRAFT DAMPER
STANDBY FAN
F-2
TO BATTERY ROOM
D-1
FROM OTHER HOODS
F-1
EXHAUST TO OUTSIDE
D-2
AIRFLOW SWITCH
RECIRCULATED AIR
12" - 24"
6" MIN ALL AROUND
D-3
OUTSIDE AIR
UPS UNIT
FILTER

FIGURE LS-2. PARALLEL FAN ARRANGEMENT. (5) 3-3-14

guidance

BATTERY LS10


ANTENNA
LS 15
Cryptography
LS6
Operations
LS5
Tech Control
TC1
Maintenance Admin.
LS14
NCOIC
TC2
Battery
LS10
Maintenance
LS7
Systems
TC2
Training
LS4
UPS
LS9
Storage
LS13
Personnel Support/
Break
Area LS3
Generator
LS11
Mechanical
LS12
Parts
LS8
Administration
LS2
Security
LS1

function

The battery room houses batteries that help comprise the backup power system (UPS), a system designed to provide continuous power to the critical load without delay.

policy/sop

1. Battery bank. This should be used as a stored energy source for the UPS. The battery's ampere-hour rating should be high enough to support the inverter for the protection time specified with the mover for operating at rated load. The battery should meet input voltage requirements of the inverter section.

2. Construction. Batteries should be the sealed type, assembled in heat-resistant, shock-absorbing, clear plastic containers with covers cemented in place to form a permanent leak-proof seal. Covers should be fitted with explosion-resistant vent caps. Cell post and cover should be sealed by lead-alloy steel nuts. Cell terminal posts should be equipped with connector bolts that have acid-resistant nuts. Enough sediment space should be provided so that the battery will not have to be cleaned during its normal life. Electrolyte level lines shall be marked on all four sides of the container.

3. Ground protection. The battery should have a high-resistance ground and a ground detection alarm for maximum safety; this will be an integral part of the UPS.

4. UPS batteries should be isolated from machinery in a properly designed battery room to prevent their damage from vibration, pollution, overheating, or explosion.

5. Battery Rack: At all sites, the seismic category should be considered. For example, safety restraint rails are recommended to hold batteries securely in place. A minimum of category I earthquake proof racks are recommended for use at all locations.

issues and assumptions

1. Batteries versus generators for "backup" power

The use of batteries as the only backup power is impractical at high-power communications facilities. Some use can be made of batteries for backup at receiving facilities and possibly for low-power (up to 1 kilowatt) transmitter radio facilities, but even this is questionable. Normally, there will be engine-driven generators at the facility to pick up the load within approximately 1 minute of the power failure. Maintaining large banks of batteries for use during an occasional power outage may not be cost-effective. (87) Vol 2, 86

activities

1. Inspecting battery system quarterly.

personnel

1. None assigned fulltime.

equipment*

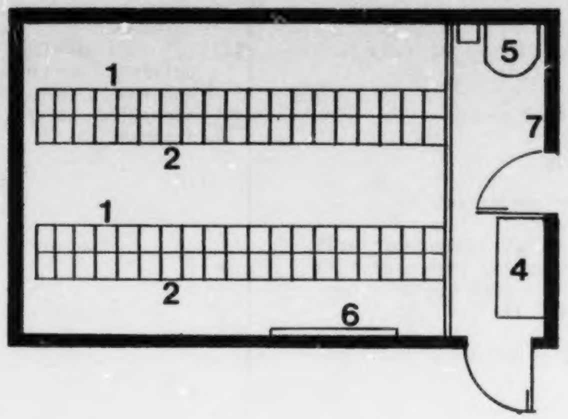
1. Lead acid batteries.
2. Battery racks.
3. Rectifier chargers.
4. Counter workbench for battery maintenance.
5. Emergency eyewash fountain and shower.
6. Safety board, 96 by 48 inches, wall-mounted.
7. Four cans of soda and four jars of distilled water.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for batteries and rectifier chargers to contain the proper safety equipment associated with the battery function.	**1.** Approximately 900 square feet are needed to provide space for battery racks, emergency eyewash, and shower equipment.	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Concrete, hardened and sealed. The battery room requires treatment with an acid-resistant floor hardener. Base--Not applicable. Walls--Paint with tile wainscot of 48 inches. Ceiling--Exposed and painted.	**2.** See also Vol 2--"Site and Building Information," SB2, Interior Construction and Finishes.
3. Acoustical isolation for adjacent mechanical equipment rooms that produce variable noise levels.	**3.** Adjacent room walls should limit sound transmission to 40 decibels.	
4. Acid removal.	**4.** A special drain system is needed to accommodate acid spills. Provide a curb to contain acid and keep it from entering the shower drainage area.	**4.** The battery room contains highly explosive fluids and fumes. It is important that item specifications be explosion-proof and meet Occupational Safety and Health Administration (OSHA) regulations. Recommend a pumpable acid holding tank that will hold up to 50% of acid volume.
5. Safety board.	**5.** Use 96- by 48-inch mounted board for assigned safety gear and a large enough floor area to store four cans of soda and four jars of distilled water.	
6. Separate exhaust ventilation system to outside.	**6.** An interlock must be provided to deenergize charging circuits if ventilation fails or shuts down. See SB2, Special Mechanical Systems, for ventilation rates.	**6.** Certain host nations require explosion proof exhaust fans and separate incoming air vents directly from the outside.
7. Adequate lighting.	**7.** Use 60-footcandle fluorescent lighting in corrosion-proof fixtures.	
8. Thermal comfort.	**8.** Maintain temperature at 60°F for heating. 104°F is the maximum allowable temperature.	**8.** See also Vol 2, SB2, Communication Station Buildings, Mechanical.
9. Electrical power.	**9.** Provide 120/208 electrical service. All 120-volt fixtures and switches are to be Class II. Locate one receptacle for every 10 linear feet of wall. Metal battery racks will be grounded to the earth ground system. (Explosion-proof electrical receptacles and fixture explosion venting are not required, but are recommended.)	**9.** See also Vol 2, SB2, Communication Station Buildings, Electrical. Air Force recommends no receptacles in Battery and will not usually use electrical equipment in room.

requirements	criteria	commentary
10. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**10.** Interior enclosure walls--1-hour fire-rated construction Interior doors--20-minute fire-rated doors Interior finish--Class A or B only Automatic fire suppression--Water sprinklers Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility Explosion-proof electrical receptacles and fixture explosion venting.	**10.** See Standardized Modules--Building Design Principles and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



3 Rectifier chargers may not be physically co-located with the batteries.

guidance

1. Location

Battery rooms, consisting of cells mounted on manufacturer-supplied battery racks, are normally adjacent to the UPS equipment room. The battery room should be windowless, reasonably well insulated against heat loss and gain, and located to minimize solar gain. Frequency conversion equipment should be as close as possible to the equipment it serves. Motor generators should be located in a separate room to reduce noise levels and heat gains in operating spaces. Static converters can be located in the equipment space or operating space because they produce minimal heat and noise. (92) 12.1-12

Spatial needs

The 48-volt d.c. battery set consists of 24 cells with interconnections, mounted in a two-tier seismic-resistant rack. (Figure LS-3.)

A suitable galvanized steel rack should be furnished. Lead-plated copper interrack connectors and cell numbers should be provided. Plastic covers should be provided to insulate rails and cells. Racks should be painted with two coats of acid-resistant paint.

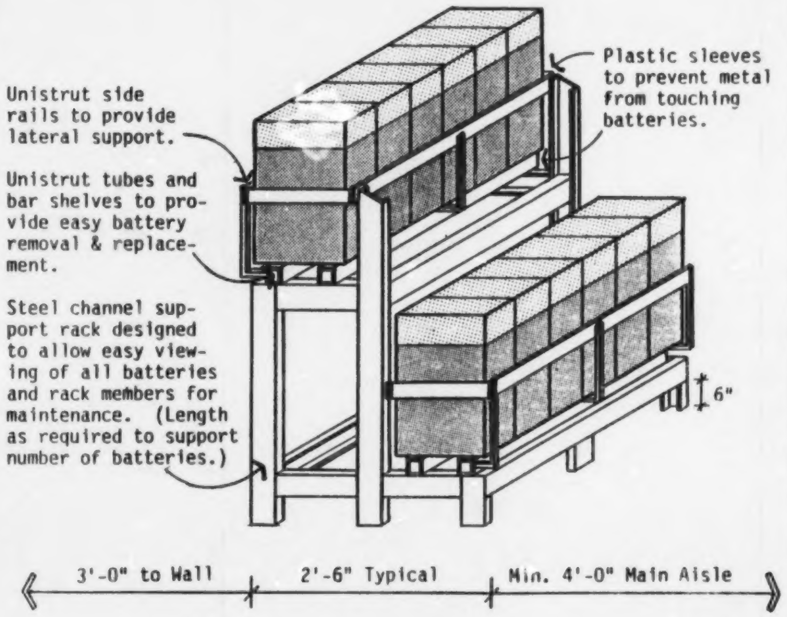

Unistrut side rails to provide lateral support.
Unistrut tubes and bar shelves to provide easy battery removal & replacement.
Steel channel support rack designed to allow easy viewing of all batteries and rack members for maintenance. (Length as required to support number of batteries.)
Plastic sleeves to prevent metal from touching batteries.
6"
3'-0" to Wall
2'-6" Typical
Min. 4'-0" Main Aisle

FIGURE LS-3. TYPICAL BATTERY STORAGE RACK

guidance

The 48-volt d.c. power can consist of two, three, or four rectifiers with storage batteries sized properly to meet each site's power requirements. The rectifiers can be operated in a parallel/redundant mode, which extends the equipment life and provides uninterrupted service should one cell fail. Rectifiers should have a "current walk-in" feature for a smooth increase in current with initial power-up to protect the load and prevent accidental circuit breaker tripping. Rectifiers also should have a current limit control that can be adjusted from 90 to 125 percent to limit the output current. A voltmeter and an ammeter can indicate rectifier operation and front panel alarm lights are available for external monitoring. Battery plant capacity should be sized to support the total load. (88)G-1

2. Durable surfaces

All floors, walls, and ceilings should be made of acid-resistant materials. Exposed concrete is recommended for the floor.

All doors to the battery room should be constructed of steel and should have a minimum dimension of 4.0 by 7.0 feet (1.22 by 2.14 meters). Consider installing a louvered bottom panel on the interior door(s).

Exhaust fans in the battery room should be covered with security bars and be explosion-proof. See SB7 in Vol. 2.

The battery room floor design load should be 250 pounds per square foot (1220 kilograms per square meter).

4. Acid Removal

All required actions must be taken to meet host country laws and regulations against the water and air pollution. An acid-resistant drain line should be installed between the battery room floor drain and the "pumpable" holding tank for chemical waste. Connections to sewage lines is unacceptable. Vent lines also should be acid-resistant.

6. Exhaust ventilation

The battery room is to be supplied with its own ventilation intake and exhaust ports to outside air. (40) 6-8

The central ventilation system supporting air to and exhausting air from the building can be used to supply air to the battery room for exhausting to the outside. (40) 6-8

Battery rooms shall be ventilated with nonsparking, explosion-proof, continuously operating exhaust fans to maintain a stable room pressure that is lower than that in adjoining rooms to prevent the outflow of contaminated air to other rooms. Required outdoor air ventilation rates for batteries and equipment shall be obtained from the manufacturer and shall be used in designing the environmental control system.

guidance

The battery room is normally ventilated by wall fans or power roof ventilators. Fans are sized so that either is adequate to limit hydrogen gas buildup to 2 percent. Both fans should have manual starters. If wall-mounted, they should be high enough to avoid hydrogen buildup near the ceiling. Backup electrical unit heaters sized to maintain a minimum temperature of 60°F (15°C) should be provided for times when waste heat is not enough to maintain the battery room temperature at its winter design level. Heaters should be on the utility or normal power circuit.

7. Lighting design

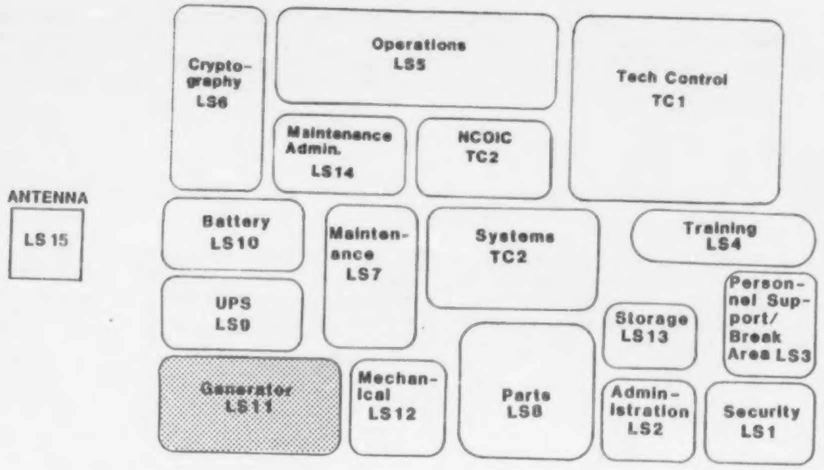
Explosion-proof fluorescent lighting fixtures should be installed in the battery room. Lighting levels in the battery room should be no less than 30 footcandles, 25 measured 30 inches from the floor. The light switch should be located outside of the battery room on the wall next to the door.

10. Life safety

A combination emergency deluge shower and eyewash fountain should be installed in the battery room.

Battery Rack: At all sites, the seismic category should be considered. For example, safety restraint rails are recommended to hold batteries securely in place. A minimum of category I earthquake proof racks are recommended for use at all locations.

GENERATOR LS11


Crypto-graphy LS6
Operations LS5
Tech Control TC1
Maintenance Admin. LS14
NCOIC TC2
ANTENNA
LS 15
Battery LS10
Mainten-ance LS7
Systems TC2
Training LS4
UPS LS9
Storage LS13
Person-nel Sup-port/ Break Area LS3
Generator LS11
Mechan-ical LS12
Parts LS8
Admin-istration LS2
Security LS1

function

Facility generators maintain power to all communication systems when the commercial power fails.

policy/sop

1. Line of Sight Microwave facilities usually will have one diesel-engine generator as a backup power source in the event of commercial power failures where redundancy in the communication linkage is already established.

   (See MIL-HDBK 411A for specific policies on the various generator classes.)

2. Primary power requirements for a communications facility are determined by the system configuration and include equipment loads (technical power), utility and domestic loads, and provisions for future expansion. The architectural engineering agency is responsible for designing the site primary power system and its distribution. One of the most economical, convenient sources of auxiliary power is the diesel-engine generator. However, an engine-driven generator requires time to start and warm up, causing a delay before taking the load after a power failure. The recommended practice is to use storage batteries to provide power instantly and economically. They are kept fully charged by the primary power source during normal operation and, when failure occurs, they assume the load instantly without interruption to service. Batteries lack the capacity to supply power for a long period of time, so it is necessary to have an auxiliary generator available. (70) 15-11

3. On-station prime power plants are considered only when the local power is either extremely unreliable or prohibitively expensive, when no power is available, or when self-sufficiency is required for survival and reliability in a wartime environment. On-station prime power plants normally use multiple sets of DOD standard family, diesel-engine generator sets for the power source. Other sources (such as wind turbines, thermoelectric generators, fuel cells, gas-turbine generators, steam-turbine generators, and nonstandard diesel-engine generators) can also be used and should be considered when requirements for a wartime DCS dictate. An onstation prime power plant will use a minimum of three engine generator sets with one set online to carry the station load, one set as a standby, and one set as a maintenance spare. A more reliable configuration is to use four or five generator sets with two online in a load-sharing mode, one as a cold standby unit and one or two as maintenance spares. When the station's standby power requirements exceed 70

policy/sop

percent of the total power requirements and the standby power is redundant, a study should be done in accordance with DOD 4270.1-M to determine if it would be more economical to provide a total energy system that produces both electrical and steam power to be used as needed. (1) 31

4. Site personnel efficiency will be improved if it is possible to locate noisy mechanical equipment, like some diesel generators, away in housing separate from working and living areas or if some other type of noise control is provided. Also, care must be taken to insure that fresh air intakes do not catch fumes or odors from sources such as diesel generators. (2) 5-25

5. All onsite power sources (generators) and substations should be located at a point in the station boundary for which security is adequate. Additional guidelines for locating power sources and substations are: (1) 32

   a. The primary onsite power source should be located far enough from the station work areas to insure acceptable noise levels as outlined by the acoustical noise requirements of MIL-STD-1472.

   b. The primary substation should be located for convenient delivery of power from an off-station source and for easy distribution of the power to onsite facilities as required.

   c. Distribution substations should be located as close as possible to the parts of the operating building they serve.

6. Total fuel storage tank capacity should be determined by local replenishment opportunities, but should hold at least a 30-day supply for primary Class A on-station generators per MIL HDBK 411A. Class C generators require a 7-day minimum supply and Class B generators require a 15-day minimum stored fuel supply. The storage tank(s) should be constructed of fiberglass and when practical, installed underground on an incline to prevent sediment accumulation. Provisions should be made for easy filling and removal of water and other sediment. (19) 13.

issues and assumptions

1. Commercial power versus generators

The mission of DCS communication facilities is to provide reliable communications 24 hours per day. Ideally, the power source for the mission equipment should be reliable, well regulated, easily maintained, and free of transients and disturbances. In actual practice, these desirable characteristics are seldom achieved on a long-term basis. Other factors to be considered in the choice of a facility power supply are:

a. Providing the best possible system for the least amount of money (cost effectiveness).

b. Standardizing for better cost effectiveness.

c. Providing easy support (maintainability). (87) Vol 2, 62

Normally, a DCS communications facility will operate from commercial power using local generators for backup. In some areas of the world, however, commercial power may not be available or if it is, it may be so unreliable as to be unusable for the technical load. Such supplies may be satisfactory for the nontechnical load (area lighting, housing, etc.). In such cases, the primary power source should consist of generators located on the facility site. (87) Vol 2, 83

2. Comparison of engine generators

The selection of an engine generator to supply an independent power source (primary and/or standby) depends on several factors. The choice is usually between a diesel and a gasoline engine. Each has properties that determine its suitability for a particular application.

The diesel engine is suitable for either continuous or part-time service. Initial cost is slightly higher than that of a comparable gasoline engine; for certain applications, however, this disadvantage is more than offset by advantages. The diesel engine is extremely rugged, uses less and lower cost fuel, has a long life expectancy, and offers maximal reliability. Reasons for these advantages include (a) diesel fuel has a higher energy content than gasoline or liquid petroleum, (b) diesel engine operating speed is approximately half that of the gasoline engine, and (c) the diesel engine does not require an electrical ignition system. The last two factors account for lower maintenance and overhaul costs for the diesel engine. Engine starting time is comparable for diesel and gasoline engines.

Gasoline engines can be used for continuous power, but are better suited for standby use. As mentioned previously, the gasoline engine has a lower initial cost, but also a shorter life expectancy. It has a higher operating speed, which wears out the engine more rapidly. It uses more and higher operating speeds, which also wear the engine out more rapidly. It uses more and higher cost fuel and is not as reliable as a diesel engine. One reason for poor reliability is that a gasoline engine uses an electrical ignition system which is subject to failure due to dampness, age, and carbon buildup. (70) 14-3

issues and assumptions

3. Level of maintenance performed

If depot level maintenance is required and authorized, an open area, benches, and special tools (torque wrenches) also are required in the generator room. This is especially true at Navy installations, which require more extensive repair onsite.

4. Above-ground versus below-ground oil storage tank

To insure protection from hostile attack, below-ground tanks provide better security for the standby power system; however, above-ground tanks are cleaned, repaired, and maintained more efficiently, effectively, and economically.

5. Sizing generator fuel tanks

Engine generator size depends on the station's power requirements. The fuel tank capacity for these units depends on the site's accessibility and the size of the engine generators. It should not be necessary to refill fuel tanks more than once a month. If inclement weather or undue hardship dictates a longer period of time between refuelings, a larger tank is recommended. The approximate rate of fuel consumption of a diesel-driven generator, in gallons per hour, can be calculated by multiplying the output in kilowatts by 0.136; this calculation will be helpful in determining the size of tank needed. (70) 14-2

activities

1. Starting the on-line generators after commercial power failure.
2. Repairing and maintaining generators.

personnel

1. Two personnel, though not in room continuously.

equipment**

1. One "set" of generators.* (Usually Class C.)
2. Batteries for startup.
3. Fuel tank with dispensing pump. (Tank capacity varies with size of generators and reliability level of primary commercial power.)

   See MIL-HDBK 411 for the specific capacity in relationship to a class of generators.
4. Alarm panel.
5. Automatic transfer switches.

---

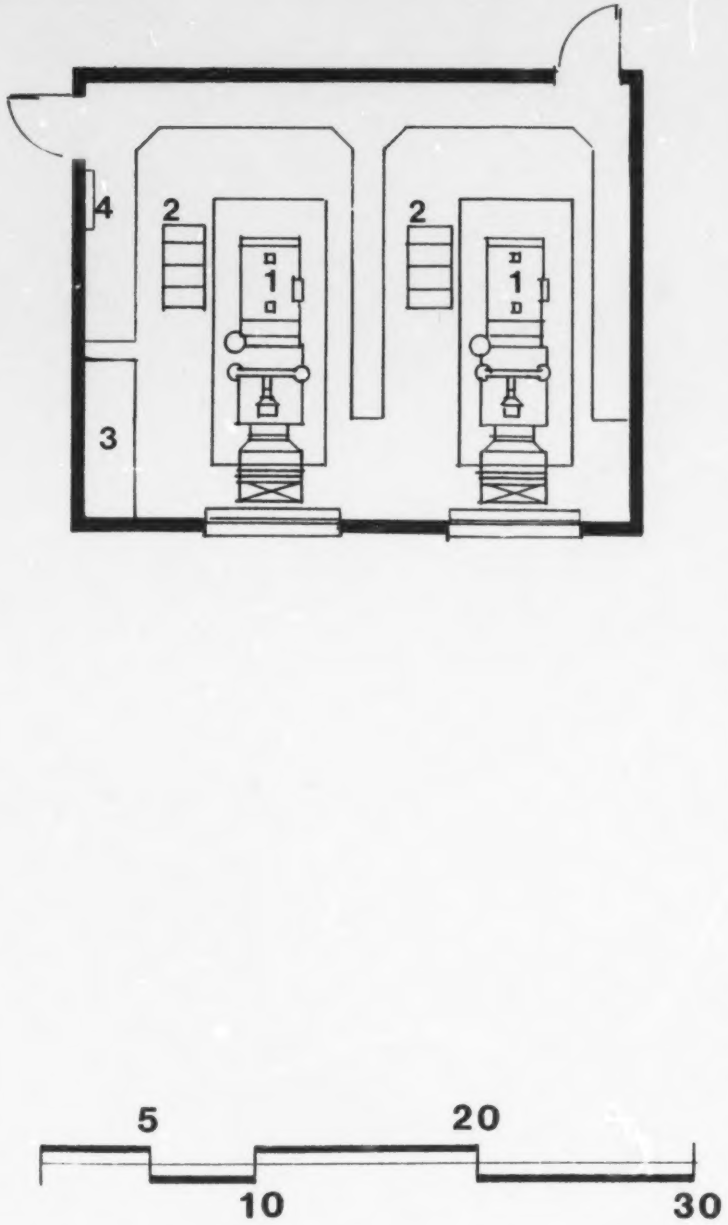
*The number and size of generators will vary among facilities depending on the voltage required to maintain the mission.

** see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for the installation, removal, and repair of standby generators.	**1.** Space needs vary with power requirements (see guidance drawing).	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustic isolation for variable noise levels produced by mechanical equipment.	**3.** Adjacent room walls should limit sound transmission to 40 decibels.	
4. Generator operation indicator and alarms.	**4.** An alarm and operation indicator panel will be located at the control console area of the operations space.	
5. Emergency lighting.	**5.** Emergency lighting should be bright enough to allow switch gear operation, instruction reading, and other mission-essential activities.	
6. Environmental control to provide generators' constant supply of make-up air for combustion and cooling.	**6.** Provide automatically adjusted louver units sized for capacity of generator selected. Exhaust stacks must be caged to prevent bird/animal entry.	
7. Vibration control.	**7.** The generators must be placed on a concrete pad physically isolated from the main floor.	
8. Design that allows complete removal and exchange of generator units.	**8.** Air intake/exhaust units should be located and sized to become a "knock-out" panel for removing a complete generator.	
9. Adequate lighting.	**9.** Use 40 footcandles (ambient). "Slow start" fixtures such as mercury vapor should not be used, nor should fluorescent fixtures.	
10. Thermal comfort.	**10.** Regulate temperature at 50°F for heating.	**10.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
11. Electrical power.	**11.** Provide 120/208 electrical service. Install 120-volt outlets; at least two duplex receptacles are required at workbench areas and at the appropriate height. Use 240-volt receptacles when required. Provide host nation standard outlets if applicable.	**11.** See also Vol 2, SB2, Communication Station Buildings--Electrical.

requirements	criteria	commentary
12. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**12.** Interior enclosure walls--1-hour fire-rated construction. Interior doors--20-minute fire-rated. Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**12.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



guidance

1. Location

If a standby generator is to operate continuously for instantaneous commercial power backup, the generator room should be located away from all normal operational spaces to isolate the noise.

> Clearances--All ducts and other systems installed in the facility as part of the finished structure should be arranged to maintain a 10-foot unobstructed clearance from the floor to the ceiling.
>
> Structural--Isolate the foundations of each generator to prevent transfer of engine vibrations to the building. Floor loading should be designed to accommodate a steady load of the heaviest auxiliary diesel engine generator designed/selected by the contractor. Pad dimensions may exceed the engine dimensions by 25 to 30 percent.
>
> Doors--All single doors should be constructed of steel and should have a minimum dimension of 4.0 by 7.0 feet. The exterior equipment door for the generator room should be double-wing type with minimum dimensions of 6.0 by 7.0 feet. This door should be equipped with a drop-in horizontal bar to secure it from the inside.
>
> Storage tank--When required, provide an underground fuel oil storage tank adjacent to the power/mechanical room. Also provide fuel oil supply and return lines, fill pipe, oil level gage, and alarm conduits. This tank must be equipped with a float switch to activate an alarm indicating a low fuel oil condition.

A single storage tank should be provided for a minimum fuel supply for both the heating boiler and diesel engine generators. MIL HDMB 411A requires Class C generators to reserve a 7-day supply, Class B generators should reserve a 15-day supply, and Class A generators should reserve a 30-day supply. A fiberglass underground tank should be used. A day tank should be provided in the building to supply fuel to both the heating boiler and diesel engine generators. (See also Vol. 2, SB1, Site Planning and Development).

Provide floor trenches in the power/mechanical room for supply and return fuel lines from the exterior fuel oil storage tank and for cable runs from the generator to the transfer switch and main distribution panel. Floor trenches should have 0.25-inch-thick steel plate covers.

guidance

4. Alarm system

Provide a wall-mounted alarm terminal panel in the generator room. The following alarms will be terminated there:

- Generator status
- Commercial power status
- Low fuel oil level (48-hour supply)
- High (80°F) or low (55°F) temperature status in communication equipment and power mechanical room
- Generator start failure.

The termination board or its associated housing should have all alarm terminations identified clearly with permanent marking or labels for future extensions of these connections to a control and fault alarm system. The alarm sensors should incorporate only dry contacts (no voltages) and should use two conductor shielded cables in the circuit runs or in conduit to the consolidated terminal panel noted above.

Provide adequate grounding cable from the building ring ground system, when applicable, to the diesel generator set metal frame and to the underground fuel oil storage tank. See Vol 2, SB4.

6. Environmental control

Generator exhausts should be located such that fumes will not be sucked into other HVAC air intakes. Emergency generators can be located inside the operations building if they are isolated properly from the rest of the structure in terms of fire protection, sound attenuation, and vibration control. (92) 12.1-12

Louvers and Openings

Provide motorized air damper openings in the generator room walls to accommodate diesel engine combustion air requirements. Dampers should automatically activate when generator starts.

Provide security bars on all openings subject to physical intrusion (greater than 7.6 feet in perimeter) such as air intake and exhaust louvers. Their attachment to the structure must be nonremovable from the exterior.

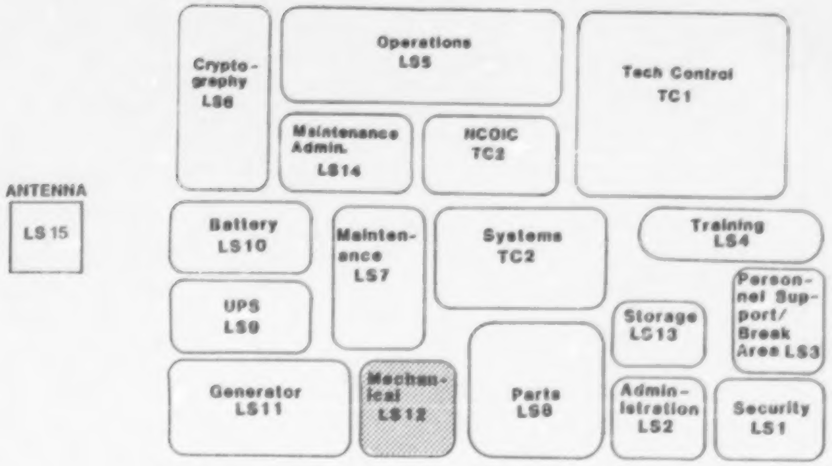
See Vol 2, SB7, for security guidance.

guidance

guidance

guidance

MECHANICAL LS12


Crypto-graphy LS6
Operations LS5
Tech Control TC1
Maintenance Admin. LS14
NCOIC TC2
ANTENNA
LS 15
Battery LS10
Mainten-ance LS7
Systems TC2
Training LS4
Person-nel Sup-port/ Break Area LS3
UPS LS9
Storage LS13
Generator LS11
Mechan-ical LS12
Parts LS8
Admin-istration LS2
Security LS1

function

This module provides space for equipment to supply all the heating, ventilating, and air-conditioning (HVAC) and water requirements for the entire facility. It must also be flexible and spacious enough to accommodate alternative energy sources.

policy/sop

1. It is desirable to provide a separate room for mechanical equipment such as heat exchangers, air-conditioners, and waveguide dehydrators-pressurizers. Heat exchangers must have air intake and exhaust ducts to the outside of the building. The size of these ducts dictates that heat exchangers must be located close to the wall. It must not be overlooked that some types of heat exchangers may require rear access for maintenance. Location of the dehydrating-pressurizing equipment is not critical. However, ease of access for maintenance is desirable and the pressure gages should be readily visible to the maintenance personnel. The air-conditioning equipment location will depend on the specific type provided and whether or not intake and outside exhaust are required. (2) 5-24

issues and assumptions

1. Calculation of space requirements

   a. Heating for each area of the facility is commonly provided by an oil-fired hot-water boiler located in the mechanical equipment room. During the heating season, hot water is supplied from the boiler to the various heating, air-conditioning, and domestic hot-water systems. In the summer, domestic hot water is provided by a small oil-fired hot-water heater and the boiler is turned off. This arrangement will add to boiler efficiency and energy conservation.

   b. Provisions will be made in the mechanical equipment rooms to allow for removal of tubes from boilers and chillers as well as the removal of coils and filters from air handling units for maintenance and replacement. All equipment will be located to allow easy access for maintenance and servicing.

   c. Usage will be 24 hours per day, 7 days per week. No special provisions for peak usage are required.

activities

1. Maintaining, controlling, and inspecting mechanical equipment.

personnel

equipment *

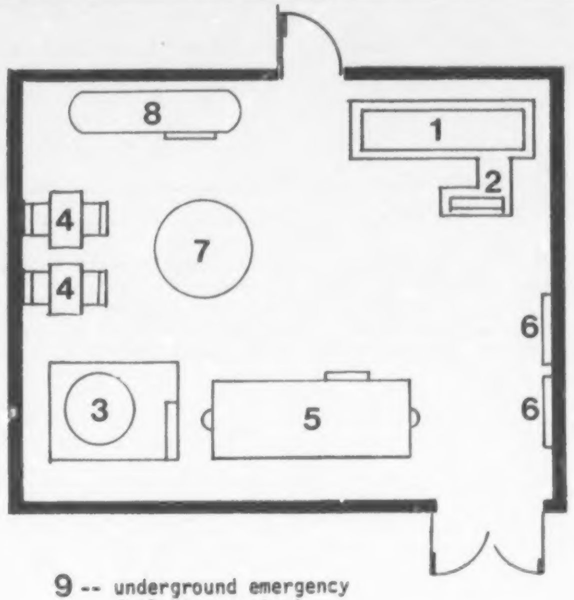
1. Chiller.
2. Condenser.
3. Compressor.
4. Water pumps.
5. Boiler.
6. Electrical switchboard.
7. Emergency water supply tank.
8. Day fuel tank.
9. Emergency fuel storage tank. (Underground--see Vol 2, SB8.)

Note: Alternative energy sources may vary and alter equipment needs. See Vol 2, SB6--AES, for information.

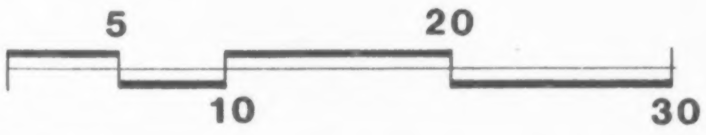
* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate the mechanical equipment requirements associated with the facility's environmental maintenance.	**1.** The ratio of mechanical equipment space to the total facility interior floor space varies from 7 percent for small facilities to about 4 percent for large facilities. (See "Issues" box.)	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation for variable noise levels produced by mechanical equipment.	**3.** Adjacent room walls should limit sound transmission to 40 decibels.	
4. Information display.	**4.** The operating instructions, preventive maintenance schedule, wiring and control diagrams, and detailed control sequence should be framed under glass or plastic and posted for easy reference.	
5. Water supply and sanitary sewer.	**5.** The water supply and sanitary sewer for this facility will be connected to the existing post systems or as prescribed for foreign locations. Provide an emergency water supply tank of 20-gallon per capita capacity for 7 days. Water must be refreshed periodically. See Vol 2, SB8, Survivability Protection.	
6. Adequate lighting.	**6.** Provide 40-footcandle fluorescent fixtures (ambient).	
7. Thermal comfort.	**7.** 50 to 68°F range (winter heating), except for batteries, which must be kept at 60 to 68°F.	**7.** See also Vol 2, SB2--Communication Station Buildings--Mechanical.
8. Electrical power.	**8.** Commercial electrical service used in the building will be site-specific. Availability depends on the host country if OCONUS. An outdoor transformer can be installed for the mechanical space in terms of general building power. Install 120-volt receptacles as needed. Electrical power must fall within the 10,000- to 500,000-watt range. Frequency levels should be at 50 to 60 hertz ± 5 percent.	**8.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
9. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**9.** Interior enclosure walls--1-hour fire-rated construction. Interior doors--20-minute fire-rated. Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**9.** See Standardized Modules--Building Design Principles, Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



9 -- underground emergency fuel storage tank outside building.



guidance

1. Storage tank

A single storage tank should be provided for a minimum 15-day supply for both the heating boiler and diesel engine generators. A fiberglass underground tank should be used. A day tank should be provided in the building to supply fuel to both the heating boiler and diesel engine generators. This tank must be equipped with a float switch to activate an alarm indicating a low fuel oil condition.

Doors--The exterior equipment doors should be steel, double swing type with steel frame. The inner opening should be at minimum 6 feet wide by 7 feet high. The equipment door should be equipped with interior locking panic hardware.

Both the exterior personnel and equipment door hinges must be welded to prevent removal of hinge pins if pivots and pins are on the outside.

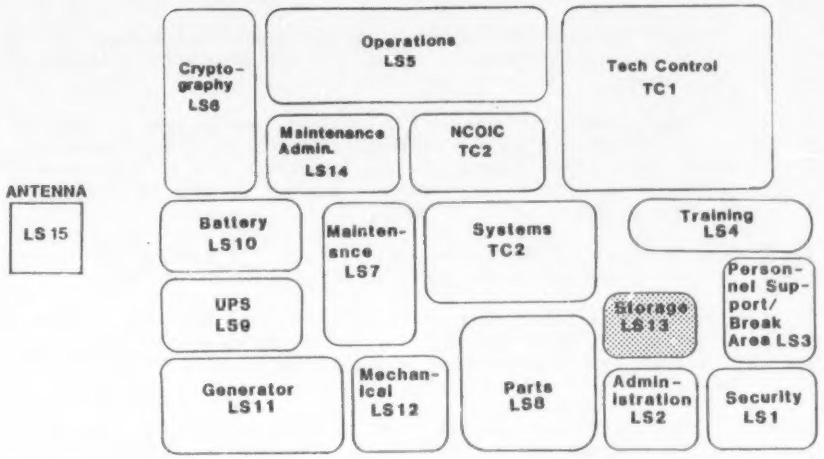
Provide security bars on all openings greater than 7.6 feet at the perimeter and subject to physical intrusion (for example, air intake and exhaust louvers). Their attachment to the structure must be nonremovable from the exterior. See Vol 2, SB7, for additional security guidance.

Structural--The minimum floor design load is 150 pounds per square foot. A clear ceiling height of 10 feet should be provided.

Mechanical equipment should be isolated to minimize vibrations. This can be done by mechanically isolating each individual system on concrete pads separate from the mechanical room floor.

Heat exchangers must be provided with air intake and exhaust ducts to the outside of the building. The size of these ducts means the heat exchangers must be located close to the wall. However, some types of heat exchangers require rear access for maintenance. Location of dehydration pressurization equipment is not critical, but ease of access for maintenance is desirable. Pressure gages should be readily visible to maintenance personnel. Location of the air-conditioning equipment depends on the specific type provided and whether intake and exhaust to the building's outside are required. (2) 5-25

STORAGE LS13


ANTENNA
LS 15
Cryptography LS6
Operations LS5
Tech Control TC1
Maintenance Admin. LS14
NCOIC TC2
Battery LS10
Maintenance LS7
Systems TC2
Training LS4
Personnel Support/ Break Area LS3
UPS LS9
Storage LS13
Generator LS11
Mechanical LS12
Parts LS8
Administration LS2
Security LS1

function

This area is for the temporary placement of miscellaneous items and nontechnical equipment.

policy/sop

1. All services have physical fitness requirements that must be met. For remote DCS facilities that have no installation services available, it is recommended that exercise equipment be made available. The exacting, sometimes intense, activities of maintaining and controlling the DCS require periodic breaks for physical exercises.

issues and assumptions

1. Storage for exercise equipment

The exercise equipment should not conflict with the function of other personnel-oriented rooms. A general purpose storage room is suitable since the equipment is unofficial.

activities

1. Shelving of miscellaneous sized items.
2. Individual exercise.

personnel

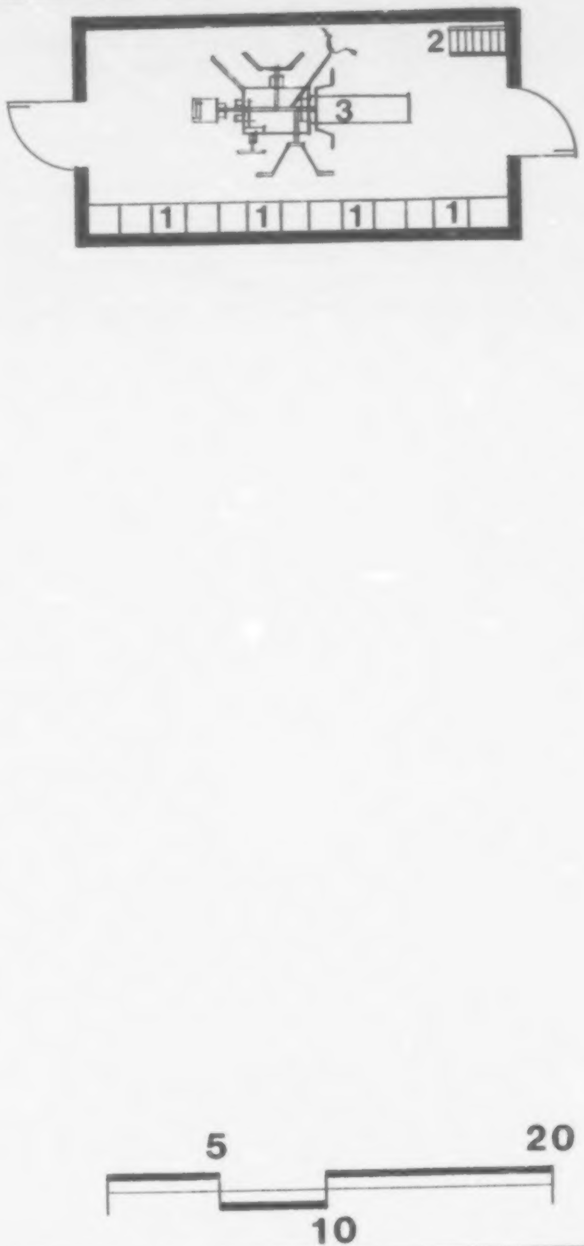
equipment*

1. Shelving 18 inches deep.
2. Small step ladder.
3. Exercycle, universal gym, and/or loose weights.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate two or three persons exercising, plus space to move about for shelving items.	**1.** Allow approximately 250 square feet to accommodate the exercise equipment plus 60 linear feet of shelf space.	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation and attenuation for a nondisruptive environment.	**3.** Adjacent room walls should limit sound transmission to 40 decibels.	
4. Adequate lighting.	**4.** Use 30-footcandle (ambient) fluorescent fixtures.	
5. Thermal comfort.	**5.** Regulate temperature at 68°F (heating), 78°F (cooling). Provide 10 cubic feet per minute per person outside air ventilation rate with on-off switching.	**5.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
6. Electrical power.	**6.** Install 120/208 electrical service. Provide 120-volt outlets--one receptacle for every 10 linear feet of wall. Frequency levels should be at 50 to 60 hertz ± 5 percent.	**6.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
7. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**7.** Interior finish--Class A or B only. Corridor finish--Class A only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**7.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance


2
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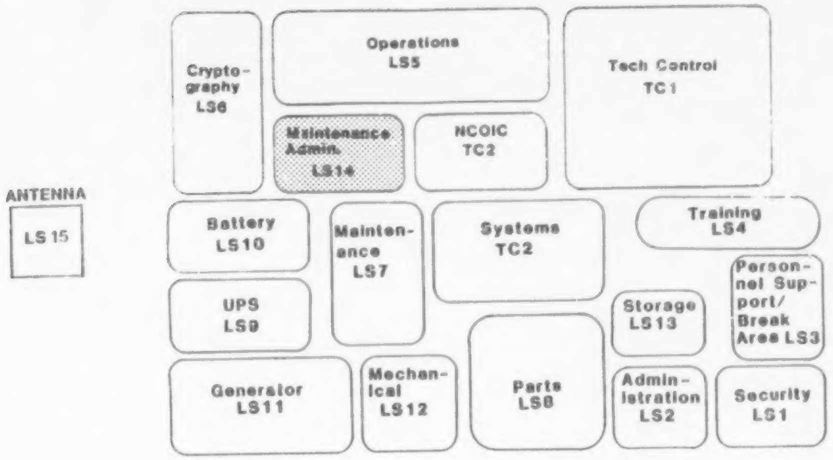
guidance

MAINTENANCE ADMINISTRATION LS14


Crypto-graphy LS6
Operations LS5
Tech Control TC1
Maintenance Admin. LS14
NCOIC TC2
ANTENNA
LS 15
Battery LS10
Mainten-ance LS7
Systems TC2
Training LS4
UPS LS9
Storage LS13
Person-nel Sup-port/ Break Area LS3
Generator LS11
Mechan-ical LS12
Parts LS8
Admin-istration LS2
Security LS1

function

To provide space that specifically supports the equipment maintenance activities of component trouble analysis and replacement.

policy/sop

1. Maintaining communication equipment requires that specific information be logged into maintenance reports, specifying type of work done, equipment used, equipment history, and parts used (inventory).

issues and assumptions

1. Automated equipment information

Upgrading the system through in-house labor would help develop maintenance personnel responsiveness. CRT's maintenance is a major function at communication facilities; therefore, large quantities of information are generated. An automated records system is needed for:

- Equipment histories (for quality control).
- Automated parts inventory.
- Manuals and specifications.
- Fault isolation for maintenance work by familiarity with the proper procedures.

activities

1. Keeping records of maintenance activity (maintenance logs).
2. Typing.
3. Filing.
4. Specification checking.
5. Parts inventory.
6. Developing maintenance personnel training plans and equipment evaluations.

personnel

1. Maintenance noncommissioned officer in charge (NCOIC).
2. Lead maintenance NCOIC. (where applicable)

equipment*

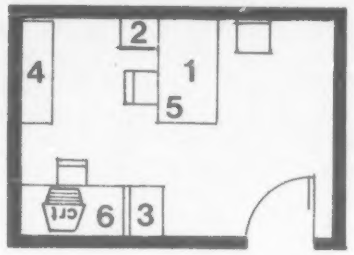
1. One desk with chairs.
2. Typewriter/word processor and stand.
3. File cabinet.
4. Shelving for manuals.
5. Telephone.
6. CRT terminal.
7. Intercom speaker.

* see "guidance" box for example layout of all equipment listed.

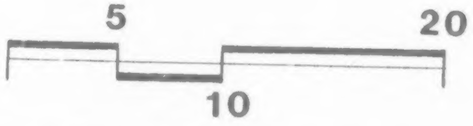
requirements	criteria	commentary
1. Enough space to accommodate the equipment and furniture associated with the administrative function.	**1.** Provide 120 square feet of enclosed administrative space.	
2. RFI/EMP/HEMP shielding.	**2.** The functional relationship of maintenance administration to the operations room may require maintenance administration to be included in the shielded/vaulted area. When this is the case, shielding is required in electrical and electronic equipment to prevent interference propagation and to protect the equipment from the interference propagated by other electronic devices. (15a) 7	**2.** See Vol 2, SB4, Grounding, Bonding, and Shielding, along with SB5, EMP/HEMP, for more information.
3. Interior finishes suitable for durability, maintenance, and room function.	**3.** Floor--Vinyl asbestos tile panels. A raised floor system shall be used over a concrete floor with a dusted-on finish that contains a hardener. See Vol 2, SB2, Interior Construction. (Only when included in the vault area.) Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	**3.** See also Vol 2, SB2, Interior Construction and Finishes.
4. Acoustical isolation and attenuation for a nondisruptive environment.	**4.** The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .90, floor surface at NRC .50, and divider partitions (if used) at .85.	**4.** See reference 201, page 3-4, Table 3-2.
5. Adequate lighting.	**5.** General lighting--20 to 50 footcandles. Task lighting--70 to 150 footcandles, adjustable arms. VDT--5 to 50 footcandles (when applicable). Surface reflectances: Ceiling--80 to 90 percent. Walls--30 to 80 percent (wall at person's back should be 10 to 20 percent). Floor--15 to 40 percent.	**5.** For further information on lighting design quality using the ESI concept, see Vol 2, SB2, Electrical Lighting.
6. Thermal regulation and other comforts for occupants.	**6.** Temperature regulation should provide 68°F (heating), 78°F (cooling), with a 5-cubic feet per minute per person outside air ventilation rate. Provide a chair with seat height adjustment, casters, swivel, and independent back rest adjustment.	**6.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
7. Electrical power.	**7.** Install 120/208 electrical service. Receptacles (120-volt) should be located for convenience at each workstation at a suitable height for every 10 linear feet of wall. Electrical power must fall within the 10,000- to 500,000-watt range. Frequency levels must be at 50 to 60 hertz ± 5 percent.	**7.** See also Vol 2, SB2, Communication Station Buildings--Electrical.

requirements	criteria	commentary
8. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**8.** Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**8.** See Vol 2, Standardized Modules--Building Design Principles, and SB3. Fire Protection/Life Safety, for more information.

guidance



7-- speaker in ceiling



guidance

5. Lighting design

To reduce glare at video digital terminals (VDTs), use fluorescent light fixtures with specular parabolic louvers. A louver with cell dimensions of 1.5 by 1.5 inches or smaller will give a high visual comfort probability (VCP) value. A diffuser along with a parabolic louver may also be helpful. Some pigmented acrylic lenses and nonparabolic metal louver panels can also have high VCP values.

The suggested cell size for a parabolic louver is 1 by 1 inch down to .5 by .5 inch. On tall ceilings, the cell depth must be greater; this may dictate a larger cell size.

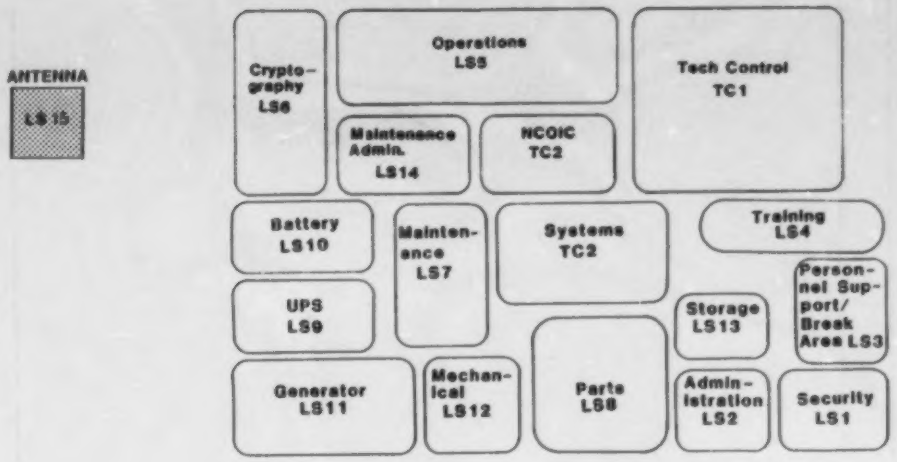
Glare from windows and reflections from walls and other surfaces must be controlled, especially on the surface immediately behind the VDT. Walls and work surfaces with a matte finish are best. Wall carpeting is also recommended for its noise control and virtual elimination of reflections.

guidance

guidance

best copy available

ANTENNA TOWER LS15


ANTENNA
LS 15
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UPS LS9
Storage LS13
Generator LS11
Mechan-ical LS12
Parts LS8
Admin-istration LS2
Security LS1

function

The purpose of this element is to support antennas and transmission lines adequately.

policy/sop

1. Lightning protection must be considered as part of each tower installation. (3)5-39
2. The antenna structures should be placed as close as possible to the equipment building, consistent with design codes and standards, to minimize the transmission line lengths required between equipment and antennas. (3)5-6
3. All towers shall provide suitable climbing facilities to the top, including access to any beacons or antennas mounted there. (70) 15-29

issues and assumptions

1. Self-supporting versus guyed towers

Microwave towers can be either self-supporting or guyed. For permanent installations and main-route, high-density use, self-supporting towers are preferred. They require less real estate than the same height guyed tower and offer more flexibility in locating the antennas, which provides for possible future antenna relocation. For temporary or tactical use, guyed towers may be more practical. The real estate required for tower guys is somewhat variable, but usually does not exceed a circle with radius equal to the tower height. Towers can be designed for almost any height; however, economical and practical considerations limit the maximal height to approximately 300 feet for wideband communications. This is not an absolute maximum, but alternatives should be carefully considered if higher towers seem to be required.

2. Parameters for tower and foundation design

Tower and foundation design depend on four main factors: (1) soil bearing capability at the specific location; (2) size and number of the parabolic antennas and their location on the tower; (3) expected meteorological conditions; and (4) the maximal tower twist and deflection that can be tolerated under worst conditions of wind loading (and ice loading if that applies). The required tower foundation design is directly related to the tower design and the specific soil conditions involved. (3)5-34

3. Tower height

The most common and important construction limitation is tower height. Towers exceeding a given height may violate local ordinances for several reasons. For example, if a link will be near an airport or in established air corridors, the site proposed may not be approved if high towers are required. Similar restrictions may apply in or near residential areas or in certain scenic areas. A very remote site may involve special construction restrictions if access roads will not permit heavy equipment (e.g., cranes) to reach the site. Certain types of construction materials may be unavailable or too expensive in some areas; in addition, special types of construction may be necessary because of local climatic conditions (as in the arctic), extremely wet regions, or in regions subject to earthquakes. (3)4-8

Except for overwater paths, a tradeoff often can be considered between high towers on a long path and an additional active or passive repeater site. This may require input from the field survey. (3)4-72

4. Tower safety

Tower safety must be insured for: (1) personnel using the structure and (2) aircraft. (3)5-38

The safety features required to protect personnel when working on the tower must be included in the tower design. Design requirements for ladders, stairs, and elevated work platforms are specified in OSHA, Volume 1, General Industry Standards. Requirements for ladder climbing safety devices are stated in AFM 127-101 and OSHA, Volume 1, General Industry Standards. (3)5-38

The hazard imposed to aircraft by the tower is minimized in two ways: (1) painting and lighting and (2) restriction against tower installation. Restriction against installation is covered by AFM 86-8, Airfield Clearance Criteria. For installation in a foreign country, the siting engineer must check for clear zone or height restrictions that may exceed those in AFM 86-8. (3)9-38

5. Antenna uses

Parabolic antennas are especially economical, combining small weight and small space requirements with low costs. Their side- and back-lobe attenuation is adequate for low-capacity systems and for single broadband radio-relay links. (3)4-188

Shell and horn-reflector antennas are more expensive, but offer a more favorable radiation pattern. Therefore, they are used mainly in broadband systems on links with many parallel RF channels and at junction stations to prevent mutual interference. (3)4-188

6. Tower material

In general, a hot-dipped galvanized-steel tower is the most desirable support for an antenna or plane reflector. This type of tower is easily shipped in sections 10 or 20 feet long, is durable, can be easily climbed, and can be procured to meet the exact height requirements. (70) 15-19

A requirement for concrete towers may be specific by certain Host Nations.

requirements	criteria	commentary
1. Mechanical stability for antennas.	**1.** To obtain the reliability required for the communication system, the structure supporting the antenna must have a long-term mechanical stability compatible with the antenna's beam characteristics. (See Guidance.) (2) 4-220	
2. Lighting protection.	**2.** Lighting protection for towers should be in accordance with the latest edition of Underwriters Lab (UL) Pamphlet 96A, Lighting Protection Systems. (2) 5-34	
3. Painting and lighting.	**3.** To prevent excessive hazards to aircraft, antenna towers and similar structures must be marked to be conspicuous when viewed from the air. Self-supporting towers should be used except in a few rare cases for which towers are extremely tall. Tower construction is important for link design and route selection, since requirements for terrain clearance determine needed tower heights. Although coaxial RF transmission lines may be used for some line-of-sight (LOS) communications, they are generally limited to frequencies of 2 gigahertz or less. A reference for additional information is MIL-HDBK-216, RF Transmission Lines and Fittings.	
4. Tower height.	**4.** Self-supporting towers should be used except in a few rare cases in which the tower is extremely high. Tower construction is important for link design and route selection; requirements for clearance over the terrain determine tower heights.	
5. Transmission line selection and protection.	**5.** Coaxial transmission lines may be used for some LOS applications, but their use is generally limited to frequencies of 2 gigahertz and below. A reference for additional information is MIL-HDBK-216, RF Transmission Lines and Fittings.	
6. Avoidance of frequency selective fading.	**6.** The avoidance depends on the quality of transmission line installation, prevention of beam intersections, and shielding from other sources.	

guidance

1. Antenna mechanical stability

The structures involved in maintaining this mechanical stability are the antenna mount and/or tower. The strength and cost of mounts and towers needed to supply the required resistance to deformation will depend on the wind velocities and ice loading characteristics of the area at which the antennas are being installed. The requirements for vertical angular stability are somewhat more stringent than for horizontal stability since, in addition to mechanical deformation, the vertical angle of arrival is also a function of atmospheric stratification. (2) 4-221

Antennas can have two possible types of unwanted mechanical displacement: elastic, such as torsional vibration and sway, and inelastic resulting from, for example, backlash in antenna mounts, changes in guy wire stress, foundation settling or the bending of structural members. The limit of elastic change in horizontal antenna orientation for an antenna mounted at the tower's top should be less than ±0.2 of a degree 99 percent of the time. The estimate of wind loading forces should be based on the time distribution of estimated wind velocities for the geographic area in which the antennas will be mounted and on the antenna aperture area. It is important to consider peak wind gusts rather than average wind velocities; also, wind velocities on high terrain or mountain peaks tend to be considerably higher than on adjacent lowlands, where climatological stations are located most frequently. (2) 4-221

Limits for horizontal inelastic movement of the tower and antenna mount should be such that the antenna's horizontal orientation will change no more than ±0.1 degree during its operational life. Even this amount of change may not be allowable for the system as a whole, since other mechanical considerations may necessitate a tighter tolerance. (2) 4-221

The tower and mount should be stiff enough that wind and ice loading do not change the antenna's vertical orientation at the top of the tower (1) elastically more than ±0.1 degree more than one percent of the time or (2) inelastically more than ±0.1 degree during the tower's operational life. (2) 4-222

Towers generally are designed for a wind load of 30 pounds per square foot of flat surface without ice coatings. For areas subject to tornadoes or hurricanes, or for which ice loads may be excessive, heavier towers are necessary. (70) 15-20

A tower's loading is the resultant of all forces acting on it. The tower design must be such that, with all antennas and other required items mounted on the tower, it will resist any deflection or twisting beyond a specified amount when subjected to maximum specified wind and ice conditions. (3) 5-34

Since the net result of all forces on the tower are also, in effect, transmitted to the foundation, the foundation must be able to distribute the force over a large enough area and depth so as not to exceed the soil bearing pressure at any point. It also must resist movement in any direction.

The foundation's height above ground will depend on groundwater conditions, but should never be less than 6 inches. In warm climates where frost is not a problem, the foundation depth will depend only on tower load and soil bearing characteristics; in colder climates, the foundation must be extended below the frost line or to firm ground. (70) 15-20; (3) 5-34

The communications engineer must the supply following type of information for the tower designer to design a suitable tower and foundation: (3) 5-35

- Size and type of antennas required and type of radomes.
- Azimuth and elevation angles for each antenna.
- Amount of adjustment required for alignment after installation.
- Height above ground for each antenna.
- Location of tower with respect to the buildings and their corresponding orientations.
- Antenna beam widths and tower twist and deflection that can be tolerated under maximum expected wind and ice loading.
- Required type and number of waveguide runs and power cabling for feedhorn or radome heaters.
- Required tower lighting, obstruction lights, lightning protection grounding systems, and paint.
- Required platforms to allow access to the antennas for maintenance and/or alignment.
- Required means of access up the tower, including required personnel safety features.
- Provisions for future antenna requirements.
- Climatic details of the area involved.
- Local restrictions and/or other constraints that may be involved.
- Soil conditions.

For systems using directly beamed paraboloids without plane reflectors, the deflection tolerance can be reduced to the same value as the twist tolerance. In general, towers designed to meet required wind- and ice-load specifications are rigid enough to meet twist and deflection tolerances. (70) 15-22

guidance

A fixed-base, self-supporting steel antenna tower should be used to support the microwave antennas when a concrete tower is not required. The tower contains an internal access ladder and rest platform landings with attached safety rails, navigational hazard lights with photoelectric control, cables and conduit, and lightning protection equipment, including air terminals, ground rods, straps, and cables. The tower also includes the antenna mounting assemblies that consist of the support framing and a 4-inch vertical pipe routed 18 inches from the face to the tower. The tower is designed to support its own dead load as well as those from the antennas and integral mounting assemblies, 2 inches of radial ice with an applied load of 125 miles per hour wind acting simultaneously, ladders, platform landings, cable ladder tray and waveguide, and a live load of 100 pounds per square foot on the platform landing. (88) Q-1

2. Lightning protection

Lightning protection must be considered as part of each tower installation. Tower grounding procedures establish an electrical connection between the tower and the earth to provide proper lightning protection. For directly beamed paraboloidal antenna systems, the waveguide path down the tower cannot be considered a reliable path to ground. Steel tower installations should be protected by a low-resistance ground connection at the tower base. When wooden poles are used for towers, copper wire should be connected from the top of the pole to a low-resistance ground arrangement at the pole's base. The steel tower should be grounded in the following way: install ground rods on opposite sides of each tower foundation at a distance no greater than 12 inches from the foundation. Use 5/8-inch-diameter ground rods, or equivalent, and drive them into the ground no less than 8 feet. Bond each leg or tower's common base to the ground rods using No. 6 AWG or larger copper wire. With the same size wire, connect the tower ground system to the station ground system. Install ground rod in the same way at each concrete guy anchor; the metal part of the guy anchor should be bonded to the ground rod. When steel or other metallic anchors are in direct contact with the earth, no additional ground rods are required. (70) 15-23

All equipment mounted on a tower shall be fastened so that it is effectively grounded through the tower. On structures provided with obstruction lights, it may be desirable to place suitable lightning arresters on the wires supplying these lights, at least between the lower part of the tower and the power supply source and, in some cases, at the top of the tower as well. (70) 15-24

As a general rule, the maximum permissible resistance between any two ground rods before connection to the tower is 2 ohms. If the resistance between rods is found to be greater than 2 ohms, it will be necessary to increase the soil conductivity. One method of lowering the resistance path between ground rods is as follows: dig a tapered trench around each ground rod. (The trench should be approximately 2 feet deep, with a bottom radius of 1 foot and top radius of 2 feet.) Then place approximately 40 pounds of rock salt in the trench and backfill it. (70) 15-24

guidance

Note: Antenna and building counterpoises must be connected in accordance with MIL-HDBK 419.

3. Tower painting and lighting

The guidelines and requirements contained in this section apply mainly to installations within the United States. At overseas installations, regulations imposed by cognizant military and/or government agencies must be studied. To prevent hazards to aircraft, antenna towers and similar structures must be marked to be conspicuous when viewed from the air. The type of marking to be used depends in part on the structure's height, location with respect to other nearby objects, and nearness to aircraft traffic routes near landing areas. Requirements and specifications for marking potential hazards to air navigation have been established through joint cooperation of the FAA, FCC, DOD, and appropriate branches of the broadcasting and aviation industries. Specifications determined by these groups aid in the final decision as to whether a structure constitutes an obstruction to air navigation. When conducting the preliminary site survey, it is advisable to determine the prevailing ordinances concerning such structures, and perhaps to discuss them with local government and building authorities. When dealing with locations within the continental United States (CONUS), the latest copies of Government Rules and Regulations, FCC Form 715, FCC Rule, Part 17, and FAA Standards for Marking and Lighting Obstructions to Air Naviation, with all revisions, should be consulted. These rules not only apply to specifications for antenna structures, but also describe the forms that must be submitted to FCC, FAA, and the U.S. Coast and Geodetic Survey (FCC Form 401A Revised, FAA Form 117, FAA Form ACA-114, and C&GS Form 844). (3) 5-40

To warn airmen about obstructions during daylight hours in good weather, all structures that may present a hazard to aircraft will be painted from top to bottom in accordance with requirements of the latest edition of FAA-AC 70/7460-1. (3) 5-41

FCC and FAA lighting specifications are given in terms of antenna structure heights. The requirements for towers and obstructions will be determined from FAA specifications in the latest edition of AC 70/7460-1. The specifications further stipulate that placement of the lights on square or rectangular towers shall be such that at least one top or side light is visible from any angle of approach. When a flashing beam is required, it shall be equipped with a mechanism that can produce no more than 40 nor less than 12 flashes per minute with a period of darkness equal to one-half the luminous period. (3) 5-41

When the tower structure is under construction, FCC and FAA require that temporary lights, consisting of at least two 100-watt lamps enclosed in aviation red globes, to be displayed at the top of the structure from sunset to sunrise. Lights must also be installed at intermediate heights if FAA requirements specify. (3) 5-42

FCC requires tower lighting to be exhibited from sunset to sunrise unless otherwise specified. At unattended microwave installations, a dependable automatic obstruction lighting control device must be provided. A light-sensitive control device will be used to control obstruction lighting when manual control is not possible. This requirement will be met in microwave installations by using a tower lighting

guidance

kit. These kits apply power to the lights when the north skylight intensity is less than approximately 35 footcandles and disconnect the power when the north skylight intensity is greater than approximately 58 footcandles. (3) 5-42

To insure the proper operation of tower lights, FCC specifies that the lights must be inspected at least once every 24 hours; the inspection can be performed either by direct observation or by observing an automatic, properly maintained indicator designed to register a lights failure. When obstruction lighting is not readily accessible for periodic inspection, the rules permit use of electric signaling devices to indicate lamp failure. Should the fault alarm system register a failure in obstruction or beacon lighting, the failure must be reported to the nearest FAA Airways Communication Station. The FAA must be notified of any code beacon, rotating beacon, or top light failure if not corrected within 30 minutes after failure. (3) 5-42

4. Tower height

Additional important questions to be considered are the type of tower that would be allowed at the site, possible hazards to aircraft, space needed, soil conditions suitable to support the required tower, and the wind and ice loading conditions. (3) 4-71

Both guyed and self-supporting tower types can be used to support the antenna or plane reflector in heights up to several hundred feet. In general, it is not economically advisable to go above 300 feet because of the rapidly increasing cost of suitable towers. (70) 15-19

For lower tower height requirements (30 to 60 feet), wooden poles of good quality, properly preserved, can be used if they are available in the required lengths. Guying arrangements should be considered to obtain the required rigidity. It is often necessary to use H-frames or other special construction techniques to attain this rigidity. (70) 15-19 In calculating tower heights, the minimum antenna height above ground should be at least 12 feet to maintain clearance of security fences, vehicles, and personnel. If sites with suitable elevations are not available or if the path is partially obstructed, clearance is obtained by increasing the antenna tower's height at one or both sites. In determining optimal antenna heights and, thus, tower height, several factors are important for systematic analysis: (3) 4-122

- Terrain clearance required for the particular path.
- Effect on atmospheric penetration angle.
- Cost.
- Antenna height requirement for adjacent paths with antenna located on the same tower.
- Limitations because of local ordinances.
- Logistics.

See MIL-HDBK-416, section 4.4.4 for more information.

guidance

5. Transmission lines

The three waveguide types common in LOS applications are:

- Rectangular.
- Circular.
- Elliptical.

Each type has certain advantages and disadvantages both from technical and economic aspects. The choice will therefore depend on the specific use and must be determined by the design engineer with consideration given to all factors involved. (3) 5-49

One disadvantage of rectangular waveguide is the many joints required in a complete run, with each joint a potential trouble point. Another disadvantage is that it will only accommodate one polarization, so in cases for which dual polarized antennas are to be used, it will be necessary to have two complete waveguide runs to the antenna. (3) 5-49

The two major advantages for circular waveguide are its low attenuation (approximately half that of rectangular or elliptical) and its ability to support two polarizations on a single waveguide run. These advantages can be of great benefit in high-capacity systems using dual polarization or when high towers are required with consequent long waveguide runs. Another desirable property is the relatively low return loss. The disadvantages are that it is essentially useful only for straight runs, requires great care in handling and installation, and demands considerably more expertise in adjusting for minimum loss and maximum polarization isolation. (3) 5-49

The advantages for elliptical waveguide are its availability in almost any continuous length and its semiflexibility. It thus offers the possibility for a long, continuous run without joints except at the two ends. Its attenuation is approximately the same as equivalent rectangular waveguide. The main disadvantages are the comparatively large bending radius required, the skill required to properly attach elliptical-to-rectangular transitions normally required at each end, and the restriction of only one polarization. Waveguide runs should be kept as short and direct as practical to minimize line loss. (3) 5-50

Other items such as circulators, isolators, filters, duplexers, and diplexers may be required in various combinations and are essentially a part of the overall waveguide system; however, one or more may also be supplied as an integral part of the radio. If any of these items are required outside the radio equipment, consideration must be given to their placement and mounting to keep the waveguide run as short and direct as possible and to minimize the need for bends and twists. (3) 5-53

All external waveguide runs should be pressurized with dry air or an inert gas. While standard tanks of nitrogen may be used for this purpose, automatic dehydrator-pressurization equipment is generally preferred. The pressure should not exceed the manufacturer's recommenda-

guidance

tion for the particular waveguide involved. This is generally on the order of 2 to 10 pounds per square inch gage. Pressure windows are available to isolate pressurized from unpressurized parts of the waveguide. (3) 5-53

The compressor-dehydrator (air dryer) provides low-pressure dehydrated air to the waveguide. The air dryer is a semiportable, electric unit that works on the principle of compression and absorption. The unit consists of a motor-driven, oilless air compressor, an air tank assembly, a self-reactivating dehydrator, a moisture trap, a pressure switch, and the gages and controls necessary to insure the delivery of dry air at the proper pressure. (88) H-1

6. Selective interference

Undesired signals radiating from transmitters on the same or adjacent frequencies to the one desired are potentially major sources of interference. These sources include satellites, satellite ground stations, radar stations, and other microwave relay systems in the same area. In addition, reflections from aircraft and precipitation act as secondary sources. Since aircraft and precipitation both move with respect to the terminals, they cause selective fading and therefore distort the wanted signal. Above 10 gigahertz, unwanted signals reflected from rain can be especially troublesome because there is a high probability that the wanted signals will be attenuated at the same time the undesired signal is reflected into the receiving antenna. Quantitative information for estimating the outages caused by these various sources often are impractical to obtain, but the following should be considered when designing a particular link: (3) 4-186

- Avoid main beam intersections with undesired sources.
- Site shielding may be effective when a site must be shared with a source of unwanted signal. Shielding can be done by advantageous location on the brow of a hill, antenna placement at a location at which the unwanted source is screened by evergreens, or by an actual cut made in a hill.
- Transmission line connections, cable, and component shielding must be designed to prevent radiation leakage. Mechanical RF switches, shutters, and probes must be avoided or, when they are necessary, must be designed carefully to prevent radiation or the picking up of unwanted signals.

guidance

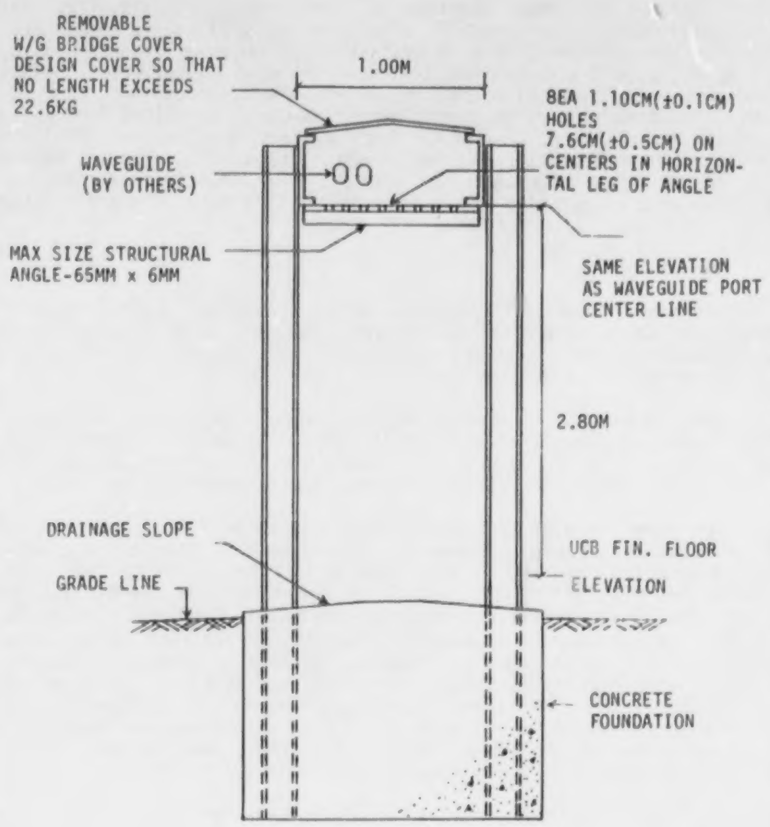
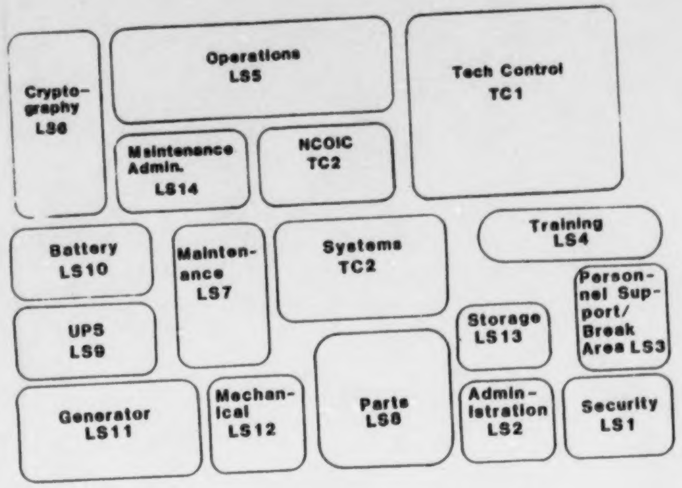

REMOVABLE
W/G BRIDGE COVER
DESIGN COVER SO THAT
NO LENGTH EXCEEDS
22.6KG
1.00M
8EA 1.10CM(±0.1CM)
HOLES
7.6CM(±0.5CM) ON
CENTERS IN HORIZONTAL LEG OF ANGLE
WAVEGUIDE
(BY OTHERS)
MAX SIZE STRUCTURAL
ANGLE-65MM x 6MM
SAME ELEVATION
AS WAVEGUIDE PORT
CENTER LINE
2.80M
DRAINAGE SLOPE
UCB FIN. FLOOR
GRADE LINE
ELEVATION
CONCRETE
FOUNDATION

FIGURE LS-4. TYPIICAL WAVEGUIDE SECTION.

guidance

guidance

STANDARDIZED MODULES LS16


Cryptography LS6
Operations LS5
Tech Control TC1
Maintenance Admin. LS14
NCOIC TC2
Battery LS10
Maintenance LS7
Systems TC2
Training LS4
UPS LS9
Storage LS13
Personnel Support/ Break Area LS3
Generator LS11
Mechanical LS12
Parts LS8
Administration LS2
Security LS1

building design principles

1. Efficiency of operational functions
   a. Communication equipment aligned for surveillance and access.
   b. On-the-job training with operating equipment.
   c. Interaction of operational support activities.
   d. Accessibility of toilets for operations personnel.

2. Integration of parts/maintenance modules with operations
   a. Parts/maintenance modules contiguous with operations spaces.
   b. Loading dock accessibility for equipment and supplies.

3. Efficiency and accessibility of administration spaces
   a. Administration transition space between public areas and secure spaces.
   b. Efficiency of integrated administrative spaces.

4. Personnel support spaces
   a. Change of environment for on-duty personnel.
   b. Facilities available for physical training.

5. Integration of power/UPS modules
   a. Economies and efficiencies of integrated power modules.
   b. Minimized impact of generators on communications transmissions.

6. Facility expansion
   a. Expansion potential in new construction operations space.
   b. Minimized impact of future operations space expansion.

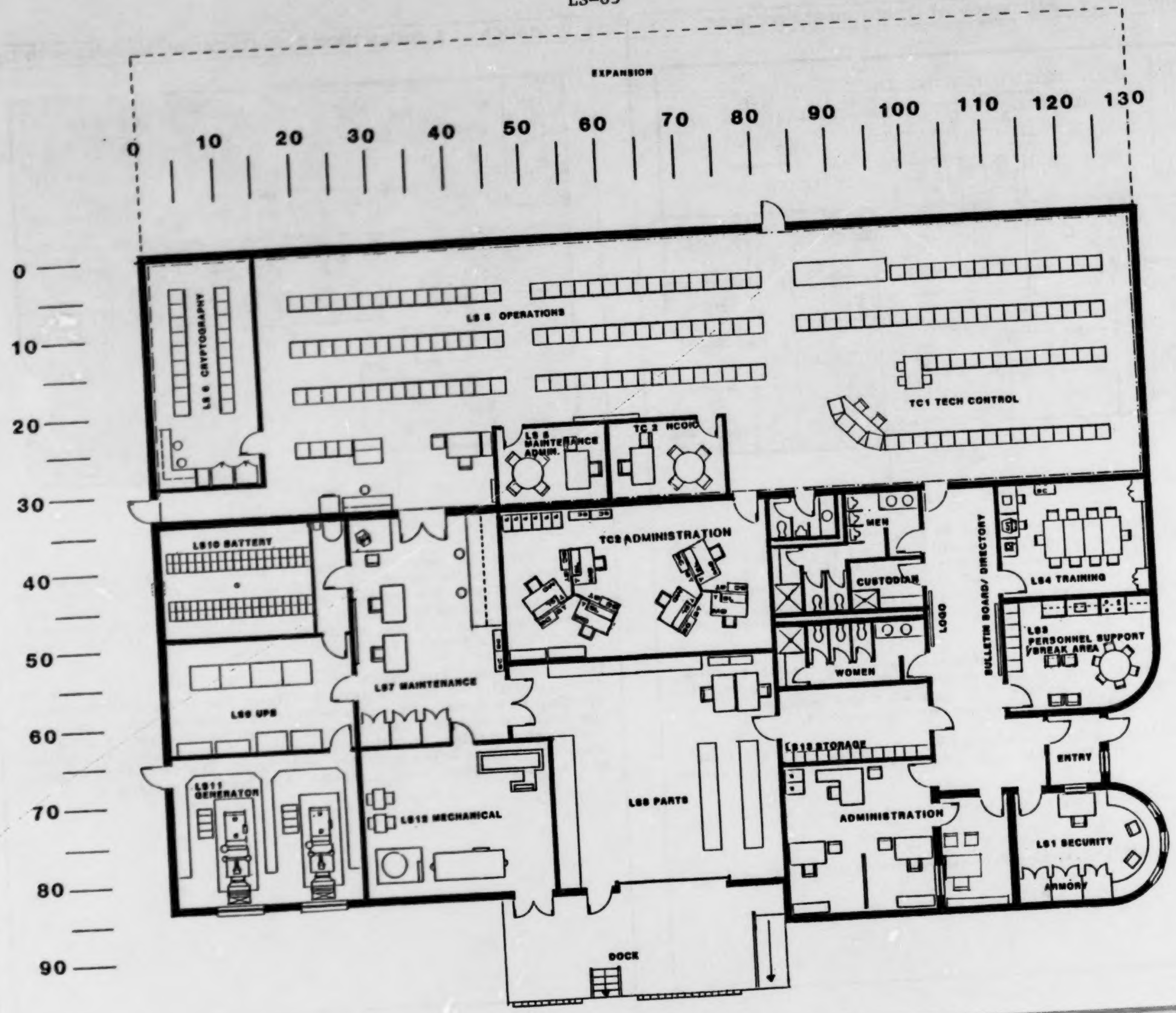
7. Security operation
   a. Location of security space to control building access.
   b. Central monitoring of total site and building security.
   c. Message security in operations and cryptography modules.
   d. Limited access into secure areas.

8. Facility security/survivability
   a. Required vault construction for communication system equipment.
   b. Protection of the communication signal.

9. Fire protection
   a. Fire protection classifications: occupancy, hazard of contents, sprinkler protection, and construction/materials.
   b. Building separation distances.
   c. Fire protection systems: automatic fire suppression, automatic notification/alarm, and automatic fire detection.

10. Life Safety
    a. Occupant load determination.
    b. Protected exit conditions: exit capacities, number of exits, exit travel distances, and means of exit arrangement.
    c. Allowable interior finishes.
    d. Egress path identification: illumination of means of egress, emergency lighting, and means of egress marking.

LS-85


EXPANSION
0
10
20
30
40
50
60
70
80
90
100
110
120
130
0
10
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30
40
50
60
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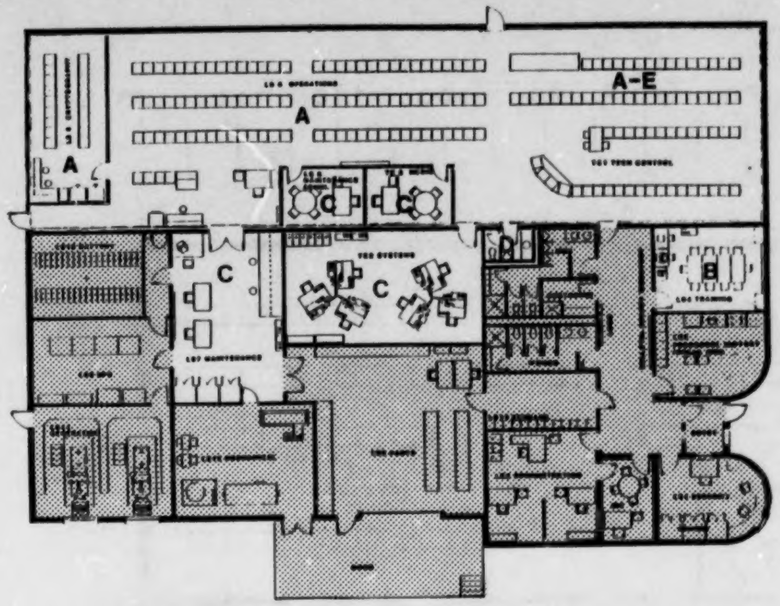
80
90
LS 6 CRYPTOGRAPHY
LS 5 OPERATIONS
TC1 TECH CONTROL
LS 8 MAINTENANCE ADMIN.
TC 2 NCOIC
TC2 ADMINISTRATION
LS10 BATTERY
LS9 UPS
LS7 MAINTENANCE
LS11 GENERATOR
LS12 MECHANICAL
LS8 PARTS
DOCK
MEN
CUSTODIAN
WOMEN
LOGO
BULLETIN BOARD/ DIRECTORY
LS4 TRAINING
LS3 PERSONNEL SUPPORT /BREAK AREA
LS13 STORAGE
ADMINISTRATION
ENTRY
LS1 SECURITY
ARMORY

guidance 1. Efficiency of Operational Functions



A. Equipment should be aligned in parallel rows within the operations modules for ease in visual surveillance and to provide direct access to all critical equipment. Multiple consoles should be adjacent to each other so that limited personnel can monitor them efficiently at one central location. Tables for audiovisual training aids should be available in operations modules so that personnel can train on-the-job during regular watch periods.

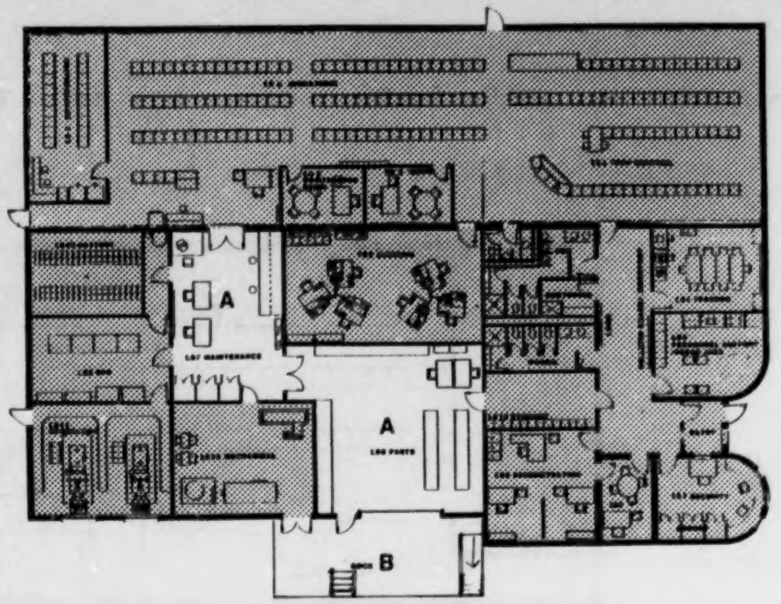
B. To further enhance the effectiveness of on-the-job training, instruction can be done in small groups of four or five in a training room for hands-on experience with communications equipment. This requires a close relationship with the operations module.

C. Additional building modules with a close functional relationship to operations activities should be located adjacent to the operations module.

D. Toilet facilities should be nearby for personnel in the operations module.

E. See technical control module information in section TC, Vol 1B.

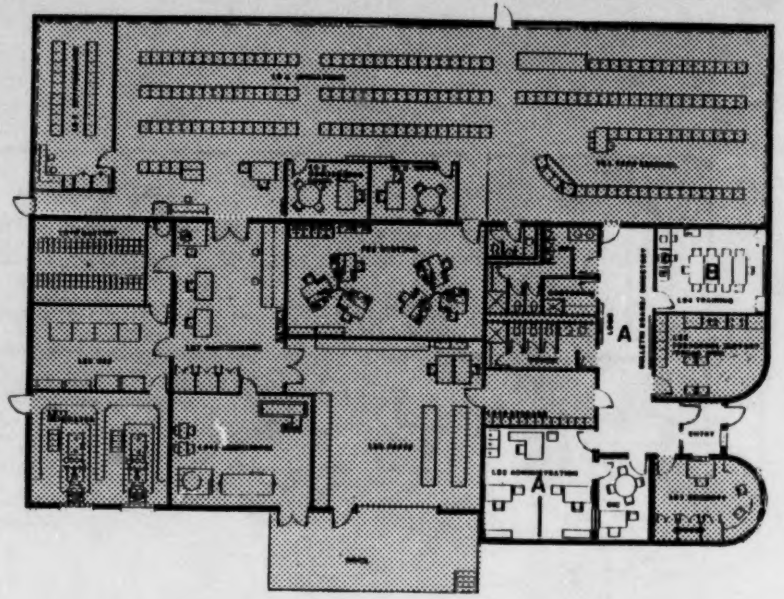
guidance 2. Integration of Parts/Maint. Modules with Ops.



A. Parts and maintenance modules should be well integrated and contiguous with the operations spaces to optimize efficiency and minimize circulation. The secure door between the operations and the maintenance/parts spaces is used only as a fire exit and to bring communication equipment in from and out to the loading dock. This door should have opening hardware only on the secure side.

B. Parts and maintenance from modules must be located within an organizational context such that deliveries can be made to the total building in a direct and secure process at a loading dock. The large communication equipment can be moved in and out more easily using the loading dock. (Also, in multistory communication buildings, an elevator should be located adjacent to the parts module for safe vertical movement of large communication equipment throughout the building.)

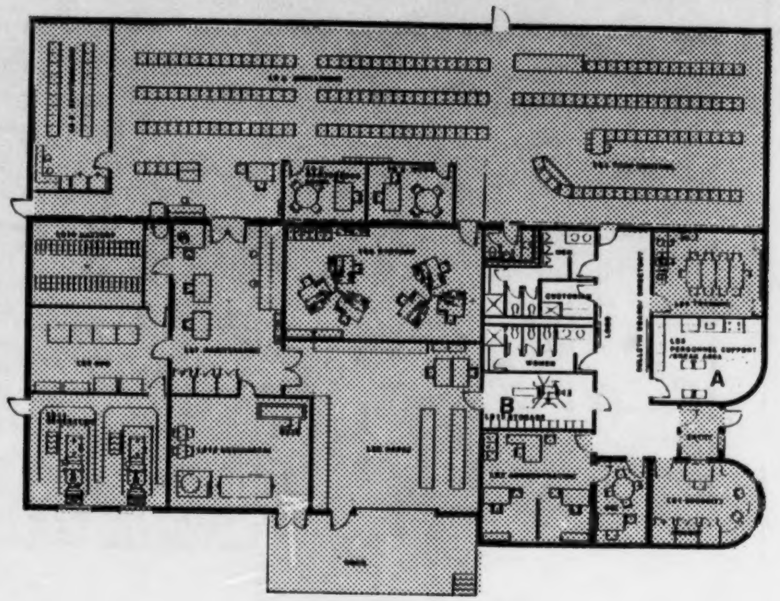
guidance 3. Efficiency and Accessibility of Admin. Spaces



A. Administration modules must be easily accessible to the public to minimize circulation and to prevent visitor interference with facility operations. The administration modules should provide a buffer and transition space between the exterior and interior secure spaces. Also, public corridors in the administration area should contain military unit logos and other display panels that relate to the "esprit de corps" and unit integrity of the communication station.

B. Administration spaces' integrated relationship will improve efficiency by minimizing public and administrative circulation and by producing a group adjacency to shared conference areas, secretaries, and waiting areas.

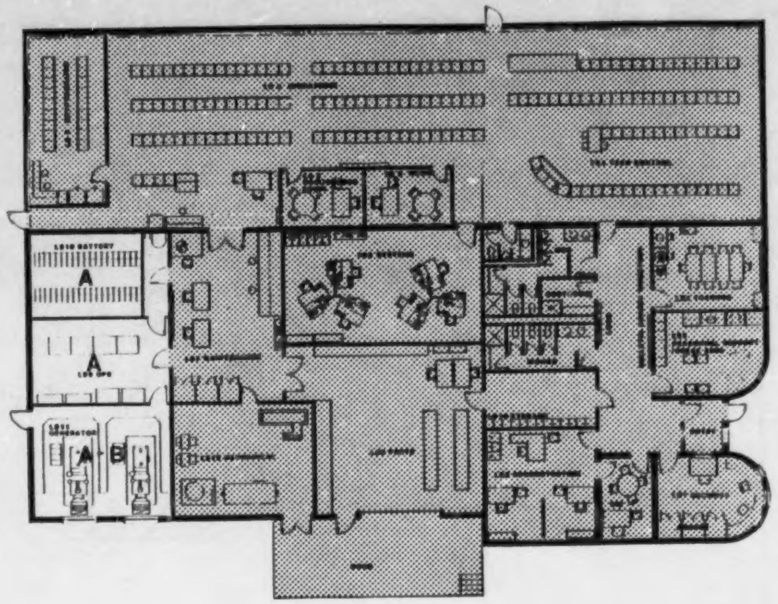
guidance 4. Personnel Support Spaces



A. The intense activities inside the DCS facility tend to generate mental fatigue among personnel. It is therefore necessary to create a change of environment for on-duty personnel to provide a break from the "hard surface" equipment room and work areas. The personnel support module should be directly adjacent to the operations room, but isolated acoustically and visually.

B. In addition, physical exercise equipment is recommended for DCS facilities located off military bases. The necessary showers and lockers should be similarly adjacent to the operations module for easy access and optimal use.

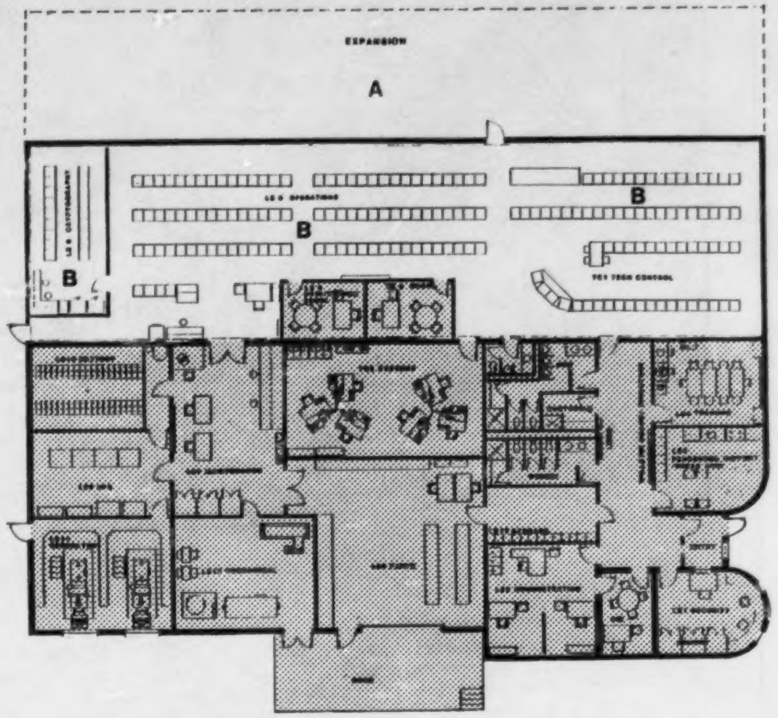
guidance 5. Integration of Power/UPS Modules



A. Modules that comprise the power and UPS gear should be contiguous and well integrated. Direct physical adjacencies provide economy by minimizing cable lengths and produce personnel efficiency through interaccess relationships.

B. Confining the power and UPS spaces to remote areas will minimize the impact of generator vibrations that could adversely affect the communications transmission.

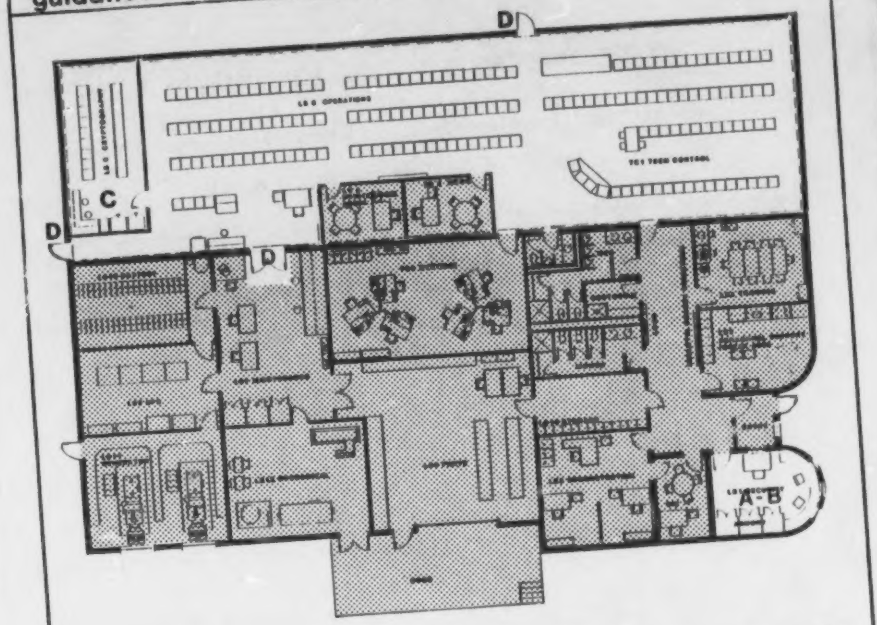
guidance 6. Facility Expansion



A. The equipment layout should be planned in a way that affords enough space for the installation of equipment capable of handling the maximum projected traffic load. The initial equipment layout should be such that the station facility's ultimate expansion can be done without extensive rearrangement of existing equipment.

B. Operations modules should be functionally isolated from support and power modules. Because of the increasingly rapid changes in communications technology, new demands on the spatial layout of operations modules can be expected in the future. Such spaces must be able to expand to accommodate new equipment and new functions. It is not anticipated that support and power spaces will need this same expansion capability and, therefore, may be located in their own areas; that is, facility design should allow operations modules to expand without greatly affecting the remaining functions.

guidance 7. Security Operation



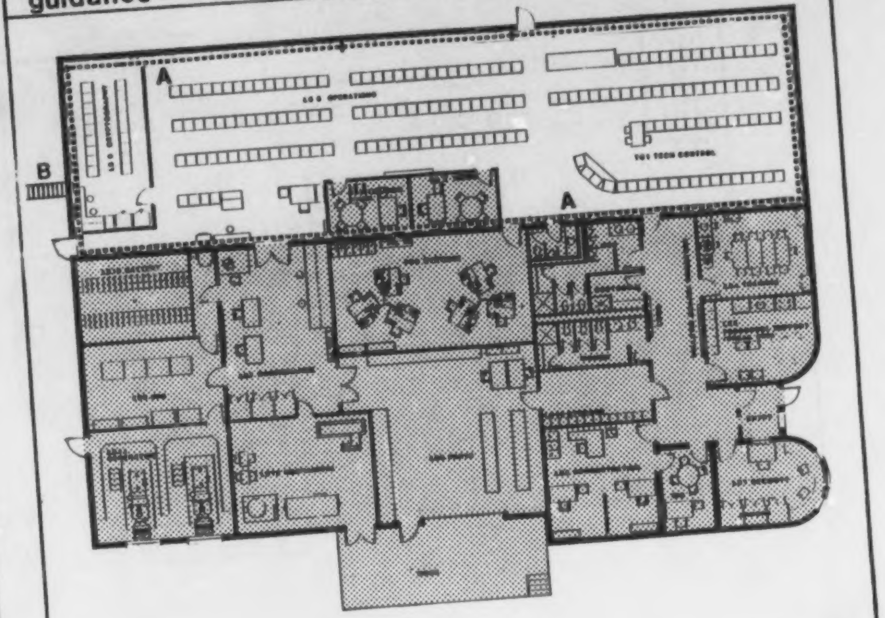
A. Security modules should be located to provide an overview for entry verification of visiting personnel. Additionally this module must be easily accessible to building occupants to facilitate efficient storage and distribution of weapons for personnel.

B. The security module will administer site security, monitor all intrusion detection systems, and initiate proper reactions to hostile threats. The security module should therefore be designed to provide overview and control over both site access and all exterior activities.

C. "Message" security is achieved by minimizing circulation between operations and cryptography modules, confining the modules to controlled areas, and providing disposal techniques to be performed or controlled by authorized personnel.

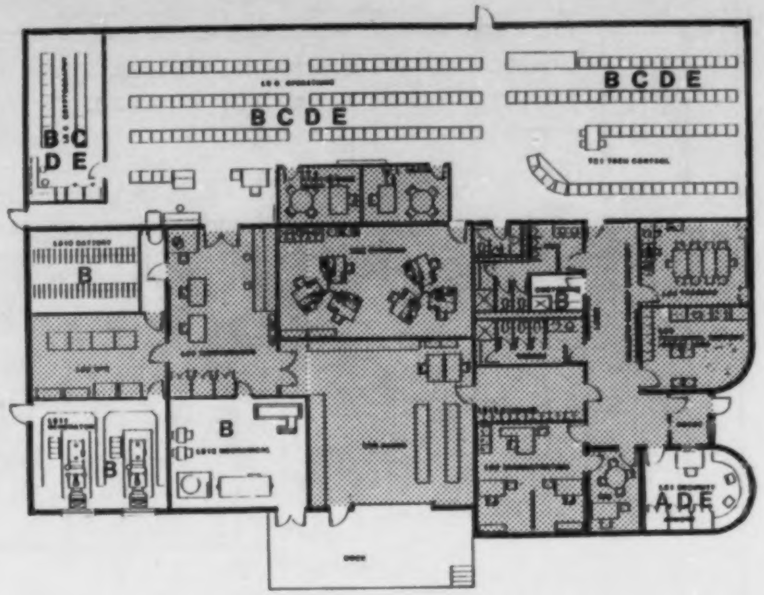
D. Required doors from other interior modules or from the outside that open into secure areas should have opening hardware only on the secure side.

guidance 8. Facility Security/Survivability



A. Conventional Class A vault construction is required for all spaces containing the communication system equipment--for example, operations, equipment, and tech control. Therefore, efficient construction methods and future building flexibility requirements can be met by locating these spaces in a contiguous relationship. These spaces usually require vault-type construction for a combination of four requirements: (1) HEMP protection, (2) TEMPEST shielding, (3) building intrusion resistance, and (4) fire protection. (See SB7, Security Systems--guidance for building security construction of Zone 4, Section 5b in Vol 2).

B. Communication facilities require waveguides in transporting the communications signal to and from the transmission/receiving equipment antennas. It is therefore necessary that the transmission/receiving module be located at a minimal distance from the antennas. In addition, waveguides must be physically protected to insure the facility's ability to perform its mission.



Occupancy classifications: Business (NFPA); B-2 (UBC)

Hazard of contents classification: Ordinary hazard

Sprinkler protection classification: Ordinary hazard--group 2.

Construction classifications/materials for fire protection (See Vol 2, the first figure in SB3, Fire Protection/Life Safety)

A. Type II--fire resistive (UBC) for security/armory spaces:

Construction Element	
Exterior walls	4-hour rated construction
Interior bearing walls	2-hour rated construction
Structural frame	2-hour rated construction
Permanent partitions	1-hour rated construction
Shaft enclosures	2-hour rated construction
Floors	2-hour rated construction
Roofs	2-hour rated construction

B. Type II--One-Hour (UBC) for battery, cryptography (RED/BLACK),* custodian, generator, operations,* mechanical, and transmission spaces:

All construction elements.......1-hour rated construction

Type II--N (UBC) for remainder of building spaces

All construction elements.......Noncombustible construction

Building Separation

Site-specific information is required. Comply with the second figure in Vol 2, SB3, Fire Protection/Life Safety.

.Interior finishes

See Guidance/Life Safety, Vol 2.

Fire protection systems

Automatic fire suppression

A water sprinkler system shall be provided throughout the entire facility.

C. A Halon 1301 or carbon dioxide system shall be provided under raised floor areas containing nonmetallic, sheathed, exposed cables when the space under the raised floor is used as an air plenum.

Automatic notification/alarm

A general alarm must be activated by the automatic sprinkler system.

D. Local alarms are required to sound only in the designated spaces; they are activated by smoke detectors.

Automatic fire detection

E. Smoke detectors are required to activate local alarms only in the designated spaces. In rooms containing raised floor areas, smoke detectors shall be located under the raised floor.

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*See Vol 2, SB7, Security, for vault construction requirements that may be more stringent than those imposed by fire protection requirements.

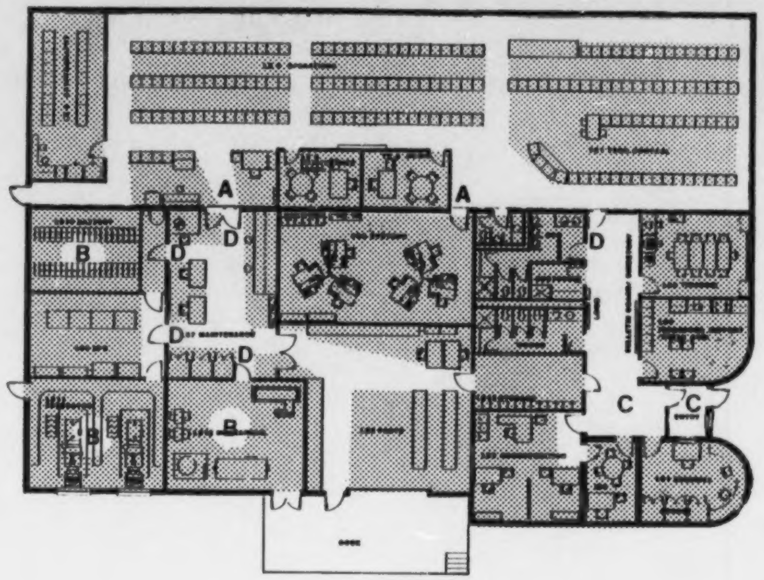


TABLE LS-1. OCCUPANT LOAD FOR DETERMINING EXIT REQUIREMENTS.

Occupant load factor: 100 square feet per person based on gross floor area (Business Occupancy-NFPA)

Occupant Load= (total facility)	$\frac{11{,}200 \text{ sq ft}}{100}$	=	112 persons
Occupant Load= (vaulted area)	$\frac{4{,}550 \text{ sq ft}}{100}$	=	46 persons
Occupant Load= (admin/support)	$\frac{2{,}650 \text{ sq ft}}{100}$	=	27 persons

Exit capacities

Corridors--100 persons per unit of exit width for travel in either direction. The minimum width of any exit access corridor or passageway shall be 44 inches in the clear.

Doors--100 persons per unit of exit width (a 3-foot door provides 1.5 units of exit width, providing an exit capacity for 150 persons).

Number of exits

No less than two exits shall be accessible from every part of every floor. One exit is permitted when the room or area has: (1) a total occupant load of less than 100 persons, (2) direct exit to an open area outside the building at the ground level, and (3) a total travel distance on the same level of not over 100 feet. (If stairs are involved, they shall be no more than 15 feet in height and shall be provided with complete enclosures to separate the stairs from any other part of the building.)

Exit travel distances

Required exits shall be located to allow access without passage through areas that may be locked. No dead end corridor shall exceed 50 feet. Travel distance to exits shall be no more than 300 feet when the building is protected throughout by an approved automatic sprinkler system.

Arrangement of means of egress

Exit access and travel routes to exits are shown in the plan.

A. Exit doors in vaulted areas that contain communications equipment are secured and permit egress out only. Exit access routes through vaulted areas from spaces outside the vaulted area are not permitted for security reasons.

B. Two means of egress shall be provided from higher hazard areas, including mechanical and generator spaces. Exit access from any other space may not pass through the mechanical or generator spaces (see exit marking). For security, when mechanical or generator spaces have exit access routes through interior spaces, exit access doors from these spaces, when opened, shall sound an alarm and transmit a signal to the annunciator panel in the security space. Access for normal maintenance in mechanical and generator spaces shall be through the exterior doors.

guidance

Interior finishes

C. Interior finish in exit access corridors shall be Class A only.

Interior finish in the remainder of the building shall be Class A or B only.

Means of egress lighting

Exits and exit access, including stairs, aisles, corridors, and passageways leading to an exit, shall be lighted continuously during times when the conditions of occupancy require means of egress to be available. Lighting should be no less than 1 footcandle measured at the floor.

Emergency lighting

Emergency lighting shall be provided in windowless buildings for designated aisles, corridors, and passageways leading to an exit. Emergency lighting shall stay at least 1 footcandle throughout the means of egress for 1.5 hours in the event of normal lighting failure.

Marking the means of egress

Exits shall be marked by an approved sign readily visible from any direction of exit access. Signs shall be placed such that no point in the exit access is more than 100 feet from the nearest visible sign.

D. Doors located or arranged so that they are likely to be mistaken for exits shall be identified by a sign reading "NOT AN EXIT."

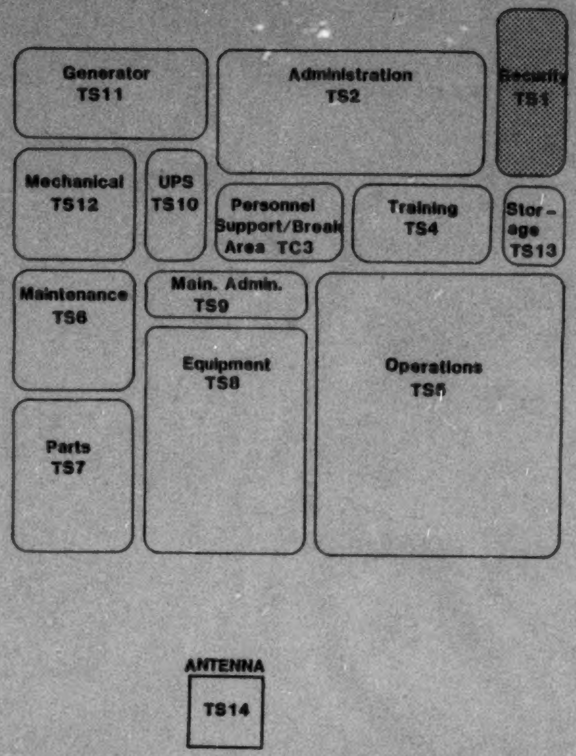
guidance

Tropospheric Scatter Microwave [TS]

TS1 Security TS-2
TS2 Administration TS-8
TS3 Personnel Support/Break Area TS-12
TS4 Training TS-16
TS5 Operations TS-22
TS6 Maintenance TS-28
TS7 Parts TS-32
TS8 Equipment Room TS-36
TS9 Maintenance Administration TS-44
TS10 UPS (Uninterrupted Power Source) TS-48
TS11 Generator TS-54
TS12 Mechanical TS-62
TS13 Storage TS-66
TS14 Antenna Tower TS-71
TS15 Standardized Modules TS-78

The dominant characteristic of tropospheric radio systems is the large, widely varying attenuation seen in the propagation of microwave signals beyond the horizon. The attenuation is so great that high system gain must be provided for successful wideband transmission; this is responsible for the most obvious features of tropospheric radio stations--the large antennas. In addition to the physically apparent features, these stations have transmitters with high power outputs at microwave frequencies and highly sensitive and selective receiving systems. They also use frequency modulation (FM) almost exclusively to provide high-quality performance with respect to effective noise reduction. The rapid, wide variations in attenuation demand a diversity of radio paths for satisfactory reception of the desired signal; therefore, a multiplicity of equipment is used at most tropospheric radio stations. (70) 6-1

SECURITY TS1



function

This component provides overview for entry verification of visiting personnel before they enter the facility. Monitoring of the Intrusion Detection System and fire alarm equipment occurs in this area. Also, where required, facility personnel weapons are stored and distributed.

policy/sop

1. The building site must be withstand intrusion by individuals or groups intending to compromise the security of the information transmitted and received at DCS facilities.

2. The overall approach to providing security in DCS sites consists of five elements. The elements of the security system are intrusion deterrence, intrusion detection, alarm assessment, component and physical plant hardening, and security or response force personnel. The intrusion deterrence element is intended to provide a psychological state of mind to a potential intruder that an intrusion will result in an unacceptable counter action. The intrusion detection element is intended to provide an alarm to the operating activity or security personnel that an unauthorized intrusion has occured at a DCS site. The alarm assessment element is intended to verify that an intrusion alarm was activated by a threat against the DCS site. The component hardening element of the physical security system is intended to cause delay in the accomplishment of damages or to limit the amount of damage that may be inflicted upon a site. The security force element is intended to delay, stop or mitigate the actions of an intruder. Every DCS site security program shall be prepared to include the five elements of the security system. (9) 4.3.3.1

3. Security alarm system should also be wired into either Tech control or the operation area spaces. These spaces will be manned 24 hours/day and could monitor the security system. The receiving/admin spaces usually are only manned 8 hours/day during the week.

4. Most OCONUS sites have local national (LN) guards that maintain security at the perimeter fence during the daytime hours. At night this function reverts to site shift communication personnel. If there are entry alarms they should be "remoted" to locations within the operations building similar to that of CCTV monitors. This will preclude assigning critical personnel to security duties. All alarm systems should be "remotable" to the operations console.

issues and assumptions

1. Full-time lighting versus "on-demand" lighting

Continuous lighting (stationary luminaires) is the most common security lighting system. It consists of a series of fixed luminaires arranged to flood a given area continuously with overlapping light cones during the hours of darkness. Standby lighting differs from continuous lighting in that standby lighting is intended to create an impression of activity. The luminaires are not lighted continuously, but are either automatically or manually turned on at random or when suspicious activity is detected or suspected by the security force or the intrusion detection system (IDS). This technique may offer great deterrent value as well as economy in power consumption. (37) 13.1-120

2. Automatic actuation of security lighting versus manual lighting

A deterrent lighting system can be developed to turn lights on at random or, rather than randomly activating the luminaires, an IDS sensor can be used to turn on the lights when an intruder is detected. This type of active lighting system provides maximum deterrent value at a low duty cycle. (37) 13.1-124 Automatic actuation of lights for normal operations seems most advantageous; however, manual override should be provided for control.

activities

1. Viewing personnel entering the complex.
2. Monitoring IDS equipment.
3. Operating facility physical security program.
4. Distributing and storing personnel weapons.

personnel

1. One.

equipment *

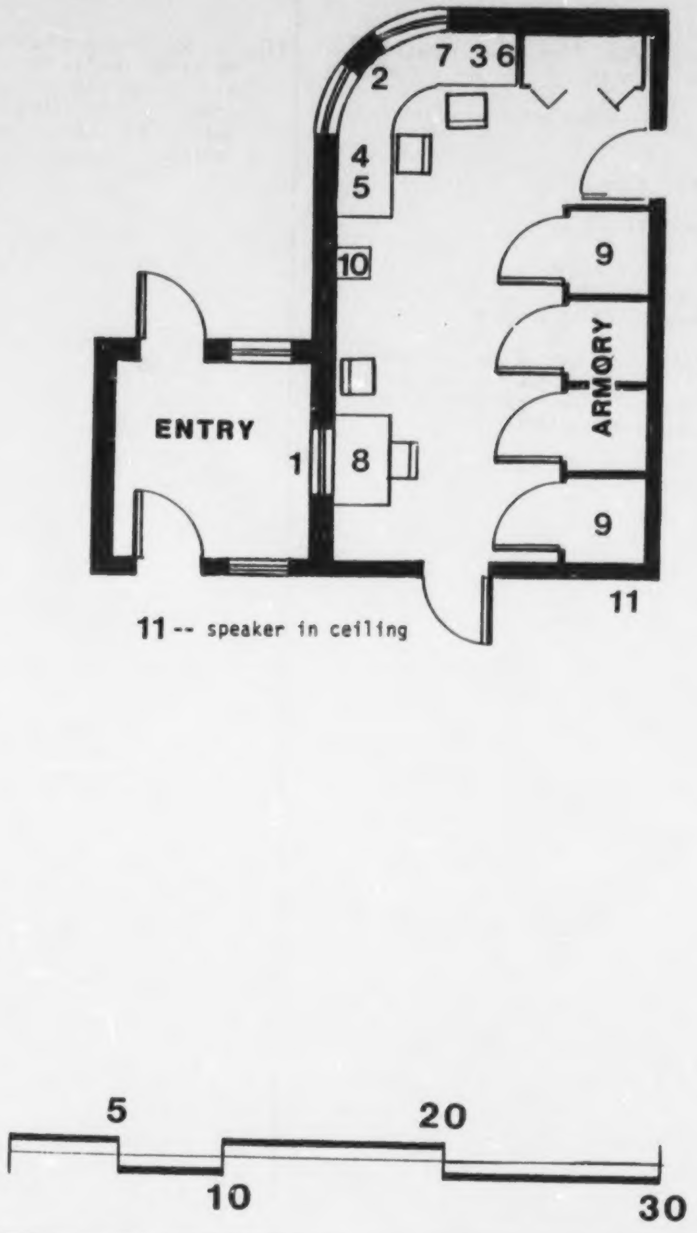
1. Pass window for identification.
2. Annunciator panel (sensor information).
3. Closed-circuit TV.
4. Gate control for perimeter security fencing.
5. Exterior lighting control.
6. Communication link to host agency.
7. Alarm for intrusion detection to host agency security office.
8. Desk (or counter unit) with chair.
9. Racks for personnel weapons. Weapon distribution is through a door with a daygate for passing through.
10. Humidifier.
11. Intercom speaker.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate IDS equipment and personnel associated with security component.	1. Provide space for one person who verifies and monitors the facility's security. This area varies with size of facility, but typically is 400 to 500 square feet.	
2. Visual verification of entering personnel.	2. Provide a pass window.	
3. Communication and electronic monitoring lines.	3. Coordinate IDS components into a centralized module. Provide an annunciator panel with telephone and intercom link-ups. The operation room console should have remote alarms along with a CCTV monitor.	
4. Resistance against penetration from the outside and for the armory.	4. Windows should be glazed and hardened to prevent penetration (bullet-proof glass). Windows also should be designed for full visibility over approaches to the point of entry.	4. See Vol 2, SB7, Security (Zone 3), for more information.
5. Interior finishes suitable for durability, maintenance, and room function.	5. Floor--Vinyl asbestos tile. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	5. See also Vol 2, SB2, Interior Construction and Finishes.
6. Acoustical isolation and attenuation for a nondisruptive environment.	6. The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum), floor surface at NRC .25 (minimum), and divider partitions (if used) at .85.	
7. Adequate lighting to review entering personnel and to monitor equipment.	7. Lighting shall be specially engineered. Low levels of lighting may be required to permit observation of luminous panels without reflected glare or undesirable contrasts in brightness. Separately controlled luminaires shall be provided for normally lighted operations and clean-up; this lighting should have an ambient level of 70 footcandles using fluorescent fixtures.	7. For further information on quality of lighting design using the ESI concept, see Vol 2, SB2, Electrical Lighting.
8. Thermal regulation and other comfort features for the occupant.	8. Maintain temperature at 68°F (heating) or 78°F (cooling) with a 5 cubic feet per minute per person outside air ventilation rate. A dehumidifier may be required in the armory. Provide a chair with seat height adjustment, casters, swivel, and independent back rest adjustment.	8. See also Vol 2, SB2, Communication Station Buildings--Mechanical.
9. Electrical power.	9. Provide 120/128 electrical service. 120-volt receptacles should be located for convenience at all workstations and workbenches at the appropriate height and for every 10 linear feet of wall. Frequency levels should be 50 to 60 hertz ± 5 percent.	9. See also Vol 2, SB2, Communication Station Buildings--Electrical.

requirements	criteria	commentary
10. Fire protection/life safety criteria are based on the assumption that this facility houses critical equipment and data that has a severe strategic fire loss potential.	**10.** Interior enclosure walls--2-hour fire-rated construction in armory, security, and entry. Interior doors--1.5-hour fire-rated doors in armory, security, and entry. Interior finish--Class A or B only. Corridor and entry finish--Class A only. Automatic fire detection--Local alarm. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**10.** See Standardized Modules-Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety for more information.

guidance



11 -- speaker in ceiling

guidance

1. Location

The minimum area is determined from IDS monitoring equipment physical dimensions.

Direct access to facility entrance is required.

This area must have no direct access to C-E equipment.

This component can be combined with the administration function in the small module package.

2. Verification

Orient windows to allow visual security of arriving personnel. In some circumstances, it works well to use mirrors to show the total front face of the building before the door is opened. This also prevents the security officer from confronting unexpected hostile action when leaving.

3. Monitoring

Three shifts in a 24-hour period are assigned for these activities if the personnel are available. At some smaller facilities, the security alarm and detection devices should also be wired into the operations, operations administration, or control monitoring space so that operation shift personnel can monitor the security system when the security space is not staffed.

Alarm system--Provide a wall-mounted alarm terminal panel in the security room. The following alarms will terminate there:

- Smoke/fire detection
- Intrusion detection of all doors and barred openings.

The termination board or its associated housing should have all alarm terminations identified clearly with permanent marking or labels. This allows future extensions of these connections to a control and fault alarm system. The alarm sensors should incorporate only dry contacts (no voltages) and should use two conductor shielded cables in the circuit runs (or in conduit) to the consolidated terminal panel noted above.

Intrusion detection system--The IDS should conform to Corps of Engineers Guide Specification CE 304.01. Provide magnetic intrusion alarm switches on all exterior doors and openings greater than 7.6 feet at the perimeter into the building. Terminate all circuits in the wall-mounted alarm panel. The door alarm is to sound then the door moves 1/2 inch toward an open direction.

guidance

The various approaches to an alarm display problem offer a wide range of capabilities, but also present several distinct disadvantages. In selecting an alarm display system for a specific installation, it is essential that the features and capabilities required for the intended application be well understood. In particular, there is no one "best" system for transmission and display of security information. Rather, a system should be selected to meet the needs of the specific installation. It should also be noted that many systems may provide more capability than is needed or desired and that paying for unused features would tend to increase the system's cost. See Vol 2, SB7, Security Systems, for more information.

4. Primary entrance door

The primary personnel entrance door should be secured with a jimmy-proof, deadbolt extension operated by a combination lock in conformance with UL Standard 768 and Military Specification MIL-L-15596. The primary entrance door should also be equipped with panic bolts and a rim with a box mullion in conformance with Federal Specification FF-H-106. The panic bolts should be UL-approved. If required for routine access control, an electrically controlled latch mechanism is authorized for installation. RF emissions should meet the requirements of MIL-STD-461 of Class II-A equipment when applicable. (5) 3-5-9

The personnel entry doors should be the steel, single-swing type with a steel frame. Another option is a door constructed of hollow metal with a 1/8-inch steel plate face.

Personnel entry doors should also be equipped with a "peephole" wide angle lens. Doors should have an inside plate to cover the peephole when it is not in use.

Hinges on both the exterior personnel and equipment doors must be welded to prevent removal of hinge pins if pivots and pins are on the outside.

7. Lighting design

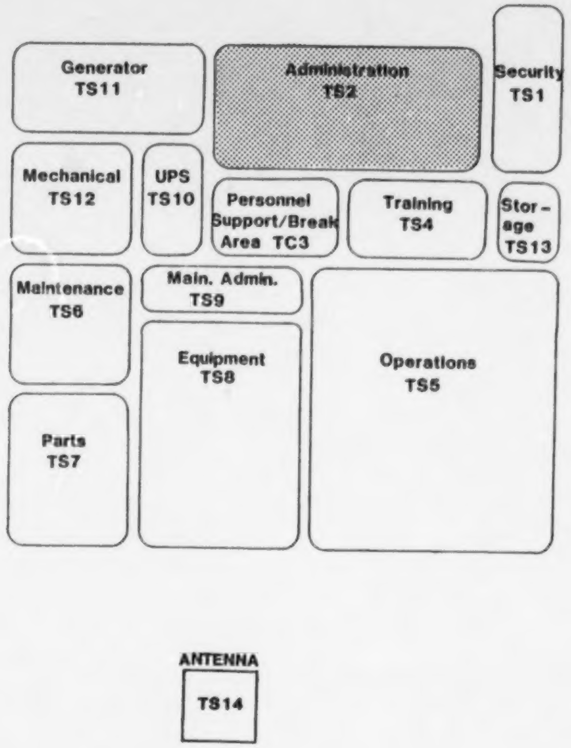
To reduce glare at video digital terminals (VDTs), use fluorescent light fixtures with specular parabolic louvers. A louver with cell dimensions of 1.5 by 1.5 inches or smaller will give a high visual comfort probability (VCP) value. A diffuser along with a parabolic louver may also be helpful. Some pigmented acrylic lenses and nonparabolic metal louver panels can also have high VCP values.

The suggested cell size for a parabolic louver is 1 by 1 inch down to .5 by .5 inch. On tall ceilings, the cell depth must be greater; this may dictate a larger cell size.

Glare from windows and reflections from walls and other surfaces must be controlled, especially on the surface immediately behind the VDT. Walls and work surfaces with a matte finish are best. Wall carpeting is also recommended for its noise control and virtual elimination of reflections.

guidance

ADMINISTRATION TS2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function

This component establishes and maintains the station administrative processing of personnel records. In addition, this section implements written and verbal SOP directives from "Chain of Command" orders, host agency regulations, and DCA policy for DCS. The administration area provides a buffer and transition space between exterior and secure interior spaces.

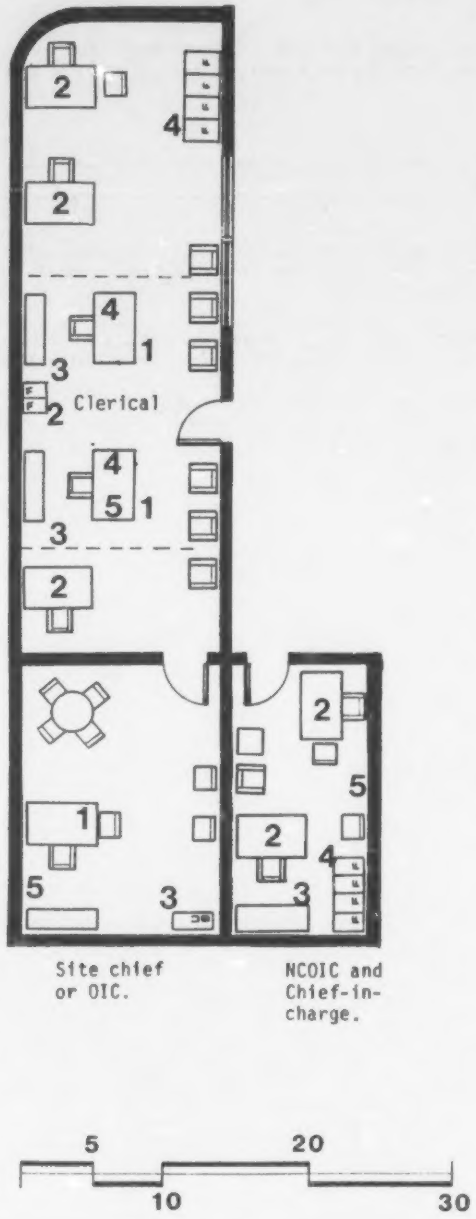
policy/sop

issues and assumptions

activities	personnel	equipment*
Officer-in-charge (OIC) 1. Distributing directives, orders, and policy statements, both written and verbal, to shift supervisors. 2. Initiating evaluation of equipment capabilities. 3. Developing personnel training plans and equipment evaluations.	1. Site chief or OIC. 2. NCOIC and Chief-in-charge. 3. Three NCO's.	**1.** Site chief workstation: • Desk/chair (enclosed) • Two side chairs • Credenza. **2.** Two NCOIC workstations: Desk/chair in open area (or with dividers). Three NCO workstations: Desk/chair in open area (or with dividers). **3.** Bookshelves--20 linear feet. **4.** Nine files with five drawers each.
Clerical 1. Typing, reception, and coordination of command/control process for the noncommissioned officer in charge (NCOIC). 2. Filing/posting of operations and personnel documents. 3. Providing courier service for paperwork.	1. One E-2 clerk (two at some installations).	**1.** Clerk workstation: Desk/chair (open area). **2.** Two files with five drawers each. **3.** Bookshelves--45 linear feet. **4.** Typewriter(s)/word processor(s). **5.** Operational voice intercom control. * see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate equipment and furniture associated with the administrative function.	**1.** Provide administrative space for supervisory personnel. This area varies with the number of assigned personnel, but is typically 1000 to 1500 square feet.	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Carpet. Base--Glazed structural units, rubber, vinyl or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation and attenuation for a nondisruptive environment.	**3.** The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum), floor surface at NRC .25 (minimum), and divider partitions (if used) at .85.	**3.** See reference 201, page 3-4, Table 3-2.
4. Adequate lighting.	**4.** Provide 80 footcandles for task lighting at work surfaces with 40 footcandles for the ambient level. Surface reflectances should be: • Ceilings--80 to 90 percent • Walls--40 to 60 percent • Floor--20 to 40 percent.	**4.** For further information on quality of lighting design using the ESI concept, see Vol 2, SB2, Electrical--Lighting.
5. Thermal regulation and other comfort features for the occupant.	**5.** Maintain temperature at 68°F (heating), 78°F (cooling), with 5 cubic feet per minute per person outside air ventilation rate. Provide a chair with seat height adjustment, casters, swivel, and independent back rest adjustment.	
6. Electrical power.	**6.** Provide 120/208 electrical service. 120-volt receptacles should be located for convenience at all workstations and workbenches at the appropriate height and every 10 linear feet of wall. Frequency levels should be 50 to 60 hertz ± 5 percent.	**6.** See also Vol 2, SB2, Communication Station Buildings--Electrical
7. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	**7.** Interior finish--Class A or B only. Corridor finish--Class A only. Automatic fire suppresion--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunicator panel and local fire department or constantly staffed station outside the facility.	**7.** See Standardized Modules--Building Design Principles and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



guidance

1. Location

Windows to the outside are recommended for CONUS facilities on secure sites, such as military installations. OCONUS facilities usually should have a minimum of windows to limit opportunities for forced entry.

Activity subspaces

- Enclosed offices
- Workstations
- Filing area
- Reception.

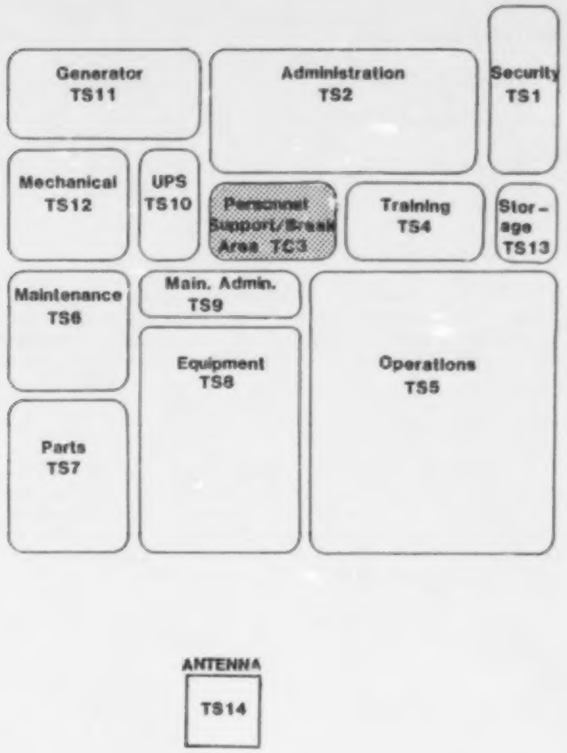
3. Acoustical and visual privacy

Divider partitions between workstations should be 60 inches high (± 4 inches) to provide visual privacy while occupants are seated--and yet should not be confining. Circulation paths around workstations should minimize disturbances to other workstations.

6. Electrical power

Workstation divider partitions can be tackboard surfaces to display maps, job examples, service equipment, and other information. Floor-to-ceiling poles are recommended to distribute electrical and communication lines to workstation modules. This eliminates floor wires at circulation paths and allows future module modifications at minimal cost.

PERSONNEL SUPPORT/BREAK AREA TS3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function

This component creates a change of environment for on-duty personnel to provide a break from the hard-surface equipment room and work areas.

policy/sop

1. The intense activities in the DCS facility generate personnel fatigue, making it necessary to separate personnel from the communication function.

2. Current policy requires personnel to have a 15-minute break every 3 to 4 hours. Typical schedules also allow 30-minute meal breaks.

3. Most communication personnel "brown bag" their meals since they cannot leave the facility during a shift. Therefore, basic food preparation capability is required: sink, hot plate, refrigerator, cabinets, and range.

issues and assumptions

activities

1. Relaxing.
2. Reading.
3. Eating.
4. Storing food.
5. Preparing food.
6. Storing personal items such as coats and books.

personnel

1. Two to eight at once.

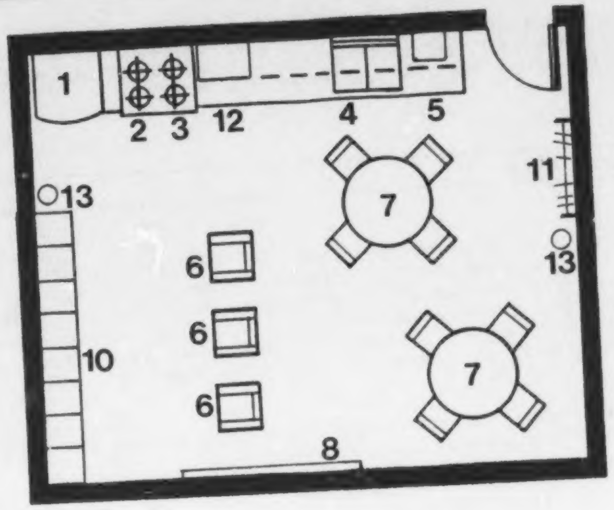
equipment *

1. Refrigerator.
2. Stove.
3. Range and range hood.
4. 20 x 30 inch sink in countertop which is a 6-foot minimum with cabinets above.
5. Coffee machine.
6. Chairs.
7. Table with chairs for eight.
8. Bulletin boards.
9. Intercom speaker.
10. Storage lockers for each person. (Not required for personnel who have private offices.)
11. Coat rack.
12. Microwave oven (if communication equipment is not affected).
13. Trash receptacles.

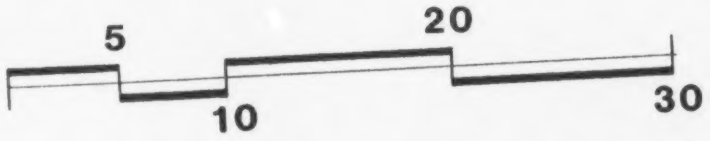
* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate equipment and furniture associated with the personnel support/break area.	1. Provide approximately 500 square feet of space for equipment and furniture to accommodate up to 15 personnel.	
2. Visual separation from the communications equipment.	2. Provide visual separation that also allows viewing of the operations area when desired. Supply comfortable furniture and carpeting (earth tones are recommended).	
3. Interior finishes suitable for durability, maintenance, and room function.	3. Floor--Vinyl asbestos tile and area carpeting. Base--Glazed structural units, rubber, vinyl or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	3. See also Vol 2, SB2, Interior Construction and Finishes.
4. Acoustical isolation and attenuation for a nondisruptive environment.	4. The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum), floor surface at NRC .25 (minimum), and divider partitions (if used) at .85.	
5. Lighting suitable for reading (task and ambient).	5. Use 20 to 30 footcandles for ambient lighting and 100 footcandles for task lighting.	
6. Thermal comfort.	6. Control temperature for 68°F (heating) and 78°F (cooling) with a 5-cubic feet per minute per person outside air ventilation rate.	6. See also Vol 2, SB2, Communication Station Buildings--Mechanical.
7. Electrical power.	7. Provide 120/208 electrical service. 120-volt outlets should be installed for every 10 linear feet of wall. Counter height outlets are required for a coffee maker, mixer, microwave oven (when permitted), and other appliances.	7. See also Vol 2, SB2, Communication Station Buildings--Electrical.
8. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	8. Interior finish--Class A or B only. Corridor finish--Class A only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	8. See Standardized Modules--Building Design Principles and Vol 2, SB3, Fire Protection/Life Safety for more information.

guidance



9 -- speaker in ceiling



guidance

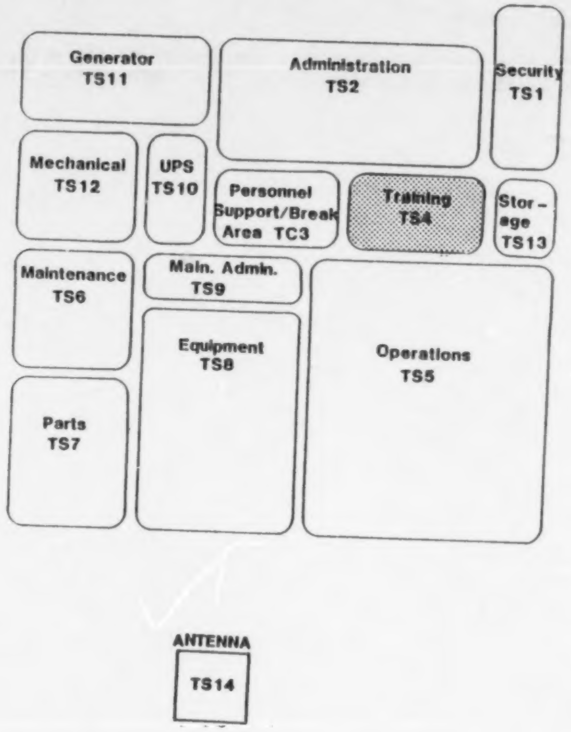
1. Location

The personnel space should be directly adjacent to the operations room, but isolated acoustically (absorptive walls) and visually (a curtain hung at the window).

3. Visual comfort

The color contrast, textures, and designs of the wall, ceiling, and floor surfaces should minimize glare for a comfortable environment.

TRAINING TS4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function

This component is for enhancing personnel abilities and effectiveness, both technically and personally. Development and implementation of the station master training program is done here.

policy/sop

1. Technical training occurs at two levels: (1) hands-on training, i.e., working directly with the communications equipment, and (2) learning from manuals, publications, and audiovisual equipment. The physical training also occurs at two levels: (1) interior individual exercise and (2) exterior small-group recreational activities, especially at remote DCS facilities that are not on a military installation.

2. Current policy requires personnel to be allowed time to train technically while on-duty at the facility.

3. Training usually is done during the times that the communication activity is at its lowest level.

4. Some communications personnel are engaged in a Career Development Course (CDC); thus, a training area is required. The Air Force counterpart is the Quick Training Package (QTP).

5. Training usually is conducted by the shift supervisor or a lead NCO/CO who is also on-duty.

6. In fire/life/safety training, safety implies the absence and/or control of conditions that can cause personal injury, death, damage to, or loss of equipment or property. Within the system, safety is concerned with the elimination or control of factors affecting the safe and efficient operation of personnel, equipment, and facilities organized to attain a common goal. The objective of safety training therefore is to insure maximum freedom from inadvertent and possibly destructive mishaps resulting from facility equipment, procedural, or personnel deficiencies during all phases of system operation. (70) 15-30

issues and assumptions

1. Three-shift versus four-shift impact on training time available

Most facilities operate on a three-shift basis:

• Day shift	8 a.m. to 4 p.m.
• Swing shift	4 p.m. to 12 a.m.
• Midshift	12 a.m. to 8 a.m.

By having personnel assigned to four shifts instead of three, one group could be a "training shift" that would be on duty during the day shift; thus, the peak activity period would have double the personnel available if required, plus give trainees the best opportunity to interact with facility functions.

The four-shift concept, however, assumes one or both of the following:

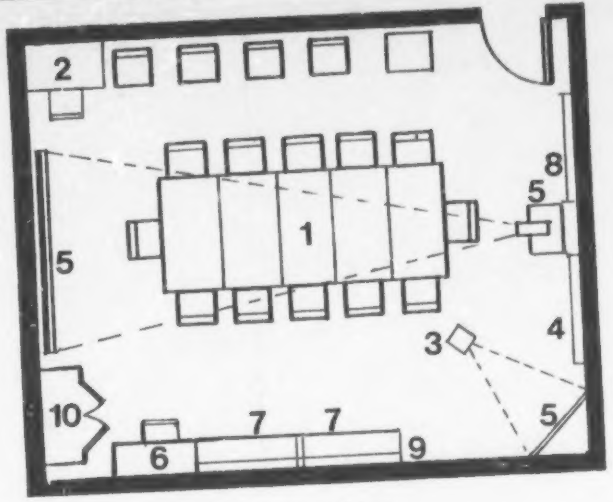
- More persons will be assigned to the site
- Staffing for the three operating shifts can be reduced.

activities	personnel	equipment *
Technical training 1. Observing and evaluating personnel records; conducting personnel interviews to determine training requirements. 2. Developing overall master training plan and presenting special MOS training module program for a specific focus. 3. Studying manuals and other publications. 4. Watching video cassettes, 16-millimeter movies, and slides. 5. Instructing in fire/life/mission safety.	Instructors 1. Commander. 2. NCOIC. 3. Civilian technicians (not an office area for personnel). *see "guidance" box for example layout of all equipment listed.	Classroom/conference room 1. Table and seating for 12. 2. TV monitor/CRT terminal. 3. Viewgraph projection. 4. Charts and display panels. 5. Audiovisual projection and screens. 6. TEC library monitors. 7. Library of written instructional materials--20 linear feet. 8. Chalkboard. 9. Tackboard for training and information bulletins. 10. Audiovisual equipment storage cabinet. 11. Intercom speaker.
Physical training 1. Involves mandatory military training requirements for physical fitness, weapons qualifications, and CBR training.		Fitness area 1. Exercise equipment: 8 by 4 foot mat, weight set, and exercycle. 2. Exterior area for volleyball and half-court basketball. 3. Athletic and recreational items; balls, bats, horseshoes, etc. 4. Intercom speaker.

requirements	criteria	commentary
Technical training		
1. Enough space for small groups (up to 20 people) that meet for small training seminars. Space for reading and studying manuals and other publications associated with the training function.	1. Provide 25 square feet of space per person. Equipment layout and storage require additional square footage.	
2. Interior finishes suitable for durability, maintenance, and room function.	2. Floor--Vinyl asbestos tile. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	2. See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation from the high noise level generated in the operations area.	3. The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum), floor surface at NRC .25 (minimum), and divider partitions (if used) at .85.	3. See reference 201, page 3-4, Table 3-2.
4. Flexible lighting.	4. Provide adjustable lighting, depending on varied uses. • 20 to 80 footcandles at each work surface. • 10 footcandles at rear of room during audiovisual projection. Surface reflectances should be: • Ceiling: 80 to 90 percent • Walls: 40 to 60 percent • Floor: 20 to 40 percent.	4. For further information on quality of lighting design using the ESI concept, see Vol 2, SB2, Electrical--Lighting.
5. Thermal regulation and other comfort features for occupants.	5. Regulate temperature at 68°F (heating), 78°F (cooling) with 5 cubic feet per minute per person outside air ventilation rate. Seating should be adjustable to provide maximal body support comfort for many different sizes.	5. See also Vol 2, SB2, Communication Station Buildings--Mechanical.
6. Electrical power.	6. Provide 120/208 electrical service. Provide 120-volt outlets--one receptacle for every 10 linear feet of wall. Specific equipment outlets depend on the room layout.	6. See also Vol 2, SB2, Communication Station Buildings--Electrical.
7. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	7. Interior finish--Class A or B only. Corridor finish--Class A only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	7. See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

requirements	criteria	commentary
Physical training		
1. Enough space to allow each person to perform physical exercises and workouts.	**1.** Minimal area of approximately 150 square feet (10 by 15 feet).	

guidance



11-- speaker in ceiling

guidance

1. Location

Since most technical training involves hands-on experience with the communications equipment, the training room should be adjacent to the operations space and should have a view into the operations space if possible.

4. Lighting design

Classroom lighting immediately in front of a lecture platform can be controlled from a point convenient to the speaker's platform and also at the entrance. Lighting can be controlled by motor-operated dimmers from the platform and the main entrance to facilitate use of audiovisual aids. Lighting can also be controlled from those points by switches. Minimum lighting shall be provided so that notes can be taken during the use of visual aids.

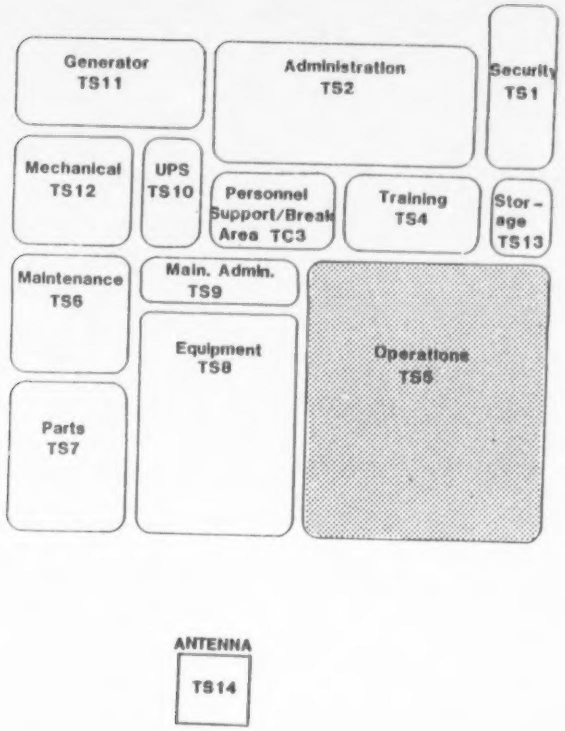
1. Physical training

See "storage" for interior physical training area guidance drawing.

guidance

guidance

OPERATIONS TS5



function

The operations room allowed personnel to operate, maintain, monitor, and repair communications equipment optimally.

policy/sop

1. Equipment and equipment layout should be standardized as much as possible among the facilities comprising a communications system. In determining the layout for facilities in which unencrypted signals bearing classified information are present or processed, the specialized installation guidance found in MIL-HDBK-232(C) must be consulted. Another major consideration is the access necessary for installation, maintenance, and operation. This would include considerations such as providing adequate space between rows of equipment to allow for opening cabinet doors or sliding out modules for maintenance. Another major, but less important, consideration is providing the shortest and most direct waveguide run practical. (2) 5-20

2. Other equipment layout considerations include minimizing interbay cabling runs, providing for future expansion, and providing easy access for maintenance and operational convenience. Sometimes the EM incompatibility of various types of equipment or inadequate ventilation for personnel and equipment can cause problems. Equipment of the same type or with similar function is usually grouped together except when impractical due to size and specific requirements of a station. (2) 5-20

3. Equipment should be grouped properly according to its function and interoperation. Care and thought should be given to the arrangement of meters, test equipment, jackfields, indicating lights, and other such items to insure they are placed approximately at eye level, thus allowing more rapid and convenient use. Equipment should not be mounted at the bottom of a bay if it can be damaged easily or if its size and shape will interfere with power boxes or other hardware at the bottom of the cabinet or rack. Most microwave radio equipment comes fully packaged with all components already mounted in a cabinet or rack. (2) 5-21

4. The station's operational plan must be studied to determine communication circuit requirements when placing each component or rack assembly. In small stations, it is recommended that the equipment be aligned in a row along, one or, if need be, both sides of the building with enough space in between to accommodate a normal floor traffic pattern. However, this type of layout generally will not be suitable in stations for which large quantities of equipment are involved. In the large station, the most practical layout is usually one in which the equipment is aligned in bays across the width of the room, with enough space between bays to permit free access to each rack assembly. (2) 5-22

issues and assumptions

1. Automated record keeping

CRTs with hardline printers can streamline paperwork by storing all circuit history files on disk. This will allow more rapid troubleshooting in-house.

2. Electromagnetic compatibility (2) 5-43

Electromagentic compatibility (EMC) is a complex subject, so that specialists often must perform the type of EMC study needed to insure the equipment or equipment layout produces no interferences or radiation hazard.

DOD is working on new regulations to control permissible levels of EM pollution of the frequency spectrum. This work reflects the concern for environmental protection. Radiation hazards also are being regulated through concern for occupational safety. Engineering agencies working for the Government must therefore know the legal and regulatory aspects of EMC and radiation hazards to meet these requirements.

Military specifications on EMC such as MIL-STD-461, -462, and -463 are intended to control and achieve an acceptable figure of merit or quality in the development of new communications equipment. They do not eliminate the need for EMC engineering in facility design. In addition to equipment quality, the frequency selection, nearness to other facilities and, to some extent, the facility design itself are variables in the interference generation problem. (2) 5-43

3. Determining the correct shielding procedure

A comprehensive approach to the shielding of equipment from radiofrequency interference (RFI) or TEMPEST involves (a) a building layout to optimize inherent facility shielding conditions, (b) suitable location of all electronic equipment and signal cables, and (c) selection of effective shielding materials and construction components.

See Vol 2, SB4, for additional guidance information.

activities

1. Monitoring communication equipment (patch and test).
2. Isolating fault.
3. Doing quality control maintenance tests.
4. Troubleshooting and patching to good equipment.
5. Identifying bad connections.
6. Writing and typing reports.
7. Conducting training sessions.

personnel

1. Operations NCOIC.
2. Two to six operators.

equipment *

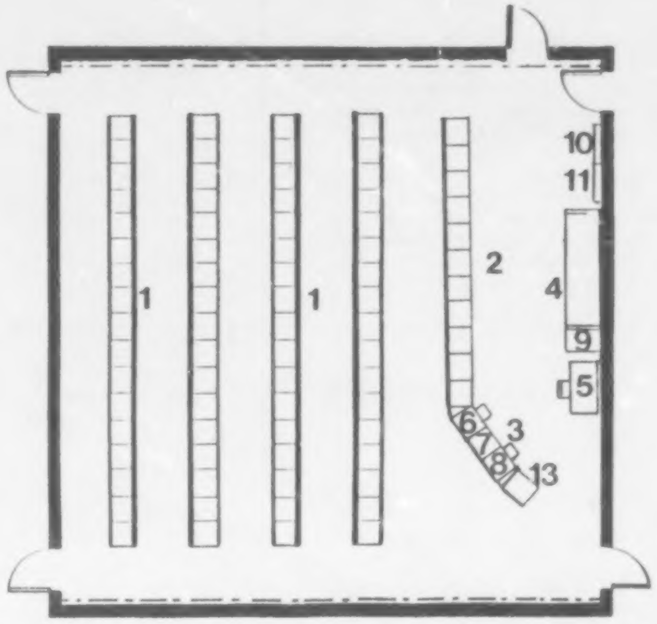
1. Electronic communication system.
2. Patch bays.
3. Control console.
4. Workbench (6 linear feet) with shelving for manuals.
5. Desk with chair.
6. CRT at console.
7. Telephones.
8. Typewriter(s) or word processor(s).
9. Filesafe.
10. Electrical shock first-aid-kit.
11. Alarm panel.
12. Operational voice intercom control.
13. Record file (10 drawers).

* see "guidance" box for example layout of all equipment listed.

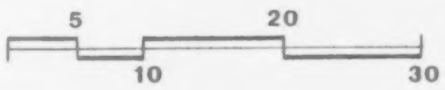
requirements	criteria	commentary
1. Adequate space for the operation and monitoring of communications-electronics (C-E) equipment. Spatial requirements must allow for proper spacing between equipment to facilitate easy maintenance.	**1.** Varies due to extent of communication equipment designed. See layout in Guidance.	
2. A secure environment for C-E equipment.	**2.** The operations room must be lockable when unstaffed and must be supplied with an intrusion alarm system. The operations console should be fitted with alarms for intrusion, power failure, and generator status. Covers should be provided on overhead rods for rapid sanitizing of applicable equipment.	**2.** See Vol 2, SB7, Security (Zone 3), for more information.
3. Signal shielding.	**3.** See Vol 2, SB4--Grounding, Bonding and Shielding along with SB7--Security Systems for more information.	
4. EMP/HEMP shielding.	**4.** Shielding is necessary for survivability and uninterrupted functioning when the facility is subjected to EM pulse (EMP) and high-altitude EM pulse (HEMP). Protective measures are based on intercepting the incident energy and dissipating it or reflecting it away from the threatened device, equipment, or facility.	**4.** See Vol 2, SB5, EMP/HEMP Protection, for more information.
5. Raised floor system.	**5.** Raised or false floors are necessary for proper cooling of the equipment.	**5.** See also Vol 2, SB2, Communication Station Buildings--Architectural.
6. Interior finishes suitable for durability, maintenance, and room function.	**6.** Floor--Vinyl asbestos tile panels. A raised floor system shall be used over a concrete floor with a dust-on finish that contains a hardener. See Vol 2, SB2--Interior Construction. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Wall--Paint over concrete, gypsum board, or plaster and acoustic tiles to within 4 feet of the floor. Ceiling--Acoustic tile.	**6.** See also Vol 2, SB2, Interior Construction and Finishes.
7. Acoustical isolation attenuation for variable noise levels produced by electronic equipment.	**7.** Adjacent room walls should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum) and floor surface at NRC .25 (minimum). Acoustic tile is also required to within 4 feet of the floor.	
8. Adequate lighting.	**8.** Lighting shall be specially engineered. Low levels of lighting may be required to permit observation of luminous panels without reflected glare or undesirable contrasts in brightness. Separately controlled luminaires shall be provided for normally lighted operations and for cleaning, with an ambient level of 70 footcandles from fluorescent fixtures.	**8.** For further information on quality lighting design using the ESI concept, see Vol 2, SB2, Electrical--Lighting.

requirements	criteria	commentary
9. Controlled environment for proper operation.	**9.** Maintain 70°F (±2°) and 50 percent relative humidity (± 5 percent continuously. Provide 5 cubic feet per minute per person outside air ventilation rate or the outside air quantity necessary to maintain a room pressurization requirement of .05 to .10 water gage.	**9.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
10. Electrical power.	**10.** Provide 120/208 electrical service and 120-volt outlets--one receptacle for every 10 linear feet of wall. Outlets for equipment should be available under the raised floor as per layout. Electrical power must fall within the 10,000 to 500,000 watt range, with frequency levels at 50 to 60 hertz ± 5 percent.	**10.** See also Vol 2, SB2, Communication Station Buildings--Electrical. Refer also to USN Manual-1983
11. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	**11.** Vaulted enclosure walls--2 hour (minimum) fire-rated, shielded construction. Interior doors in vaulted walls--1.5-hour fire-rated doors; shielded doors and frames. Interior finish--Class A or B only. Automatic fire detection--Local alarm. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility. Manual emergency equipment power shut-off at exits. Under raised floor area--Automatic fire detection: Local alarm. Automatic Halon 1301 suppression system if required for cross-zoned or matrix detection. Sprinkler and Halon systems are not normally installed in the same areas.	**11.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information. Automatic fire suppression may include Halon 1301 where specifically justified

guidance



12-- speaker in ceiling



guidance

1. Equipment expansion

It is advisable to arrange equipment in the equipment room such that future expansion of the building will not necessitate complete rearrangement. (2) 5-21

Approximately 3 feet of clearance space, as a minimum, should be allowed in front of and to the rear of an equipment bay. If a bay does not permit rear access to equipment, the bay can be installed with no clearance on the back side, that is, against a wall or back-to-back with other bays, unless ventilation requirements are compromised. (2) 5-21

5. Raised floor system

Most equipment that requires significant cooling to maintain communication operations should be located on raised floors for maximal use of coupled air directly through the cabinets. Cooling air at 60^{O}F supplied directly into the base of the transmitters will leave the top at approximately 72^{O}F. Thus, when the air exits the equipment, it is at a more comfortable temperature for persons working in the space.

8. Control area

Light fixtures should provide an approximate uniform lighting intensity of 70 footcandles and should be equipped with light control lenses or specular parabolic louvers to minimize glare on working surfaces. Lights over the area in which the control console is located shall be provided with wide-range (100:1) dimming control. (23)12

Equipment area

Fixtures should be arranged above the operating aisles and should run parallel to equipment row arrangement. They should be located so the light does not cast shadows or reflections on the front of the technical equipment and so light is not obstructed by the cable trays. Flush-mounted fluorescent lighting fixtures are recommended, and they shall be equipped with integral RFI filters (GE no. 89G635, Sprague IF-37, or equivalent). The lights shall not interfere with access to the cable trays or equipment. (23)12 Portable task lighting should also be supplied for the equipment area at 70 to 100 footcandles.

9. Protection from moisture migration

Operating spaces that contain electronic equipment usually require close temperature and humidity control. Vapor barriers placed under floor slabs and roofing usually prevent moisture migration into and out of interior electronic equipment spaces. Additional protection must be provided if exterior walls form part of the equipment space. (92)12.1-13

See also Vol 2, SB2, Special Mechanical.

guidance

Mechanical

The recommended operating temperatures and humidity conditions should be obtained from the manufacturers of the communications and data processing equipment and should be used in designing the environmental control system.

Air-conditioning

Continuous, reliable operation of any computer system depends on an efficient, well designed, properly controlled air-conditioning system. Inadequate cooling contributes as much to failure as poorly regulated power. (74) 4-17

Even though certain individual units can operate outside the limits of the overall specifications, overall environmental requirements are dictated by the most restrictive unit of the system. The computer system's requirements are the major considerations; however, good design will also consider personnel comfort. (74) 4-17

An air-conditioning system for a computer installation differs from ordinary comfort air-conditioning in the following ways. (74) 4-17

- Heat dissipation by computers is relatively constant; therefore, cooling is required year-round.
- The computer room sensible heat ratio is near unity because heat dissipated by the computer system is all sensible.
- Above-average air filtration is required to prevent errors caused by dust particles on magnetic tapes.
- The number of air changes per hour varies between 30 and 60 because of the computer equipment's high heat dissipation.
- Humidity control is required year-round to maintain necessary conditions in the computer room. However, introducing water vapor into the airstream for humidification is not recommended for electronic equipment areas because water vapor can damage electronic components. (40) 7-3

Temperature and humidity recording instruments

Recording instruments are needed to provide a continuous record of temperature and humidity in the machine area. Also, if the air-conditioning requirements are not met, a record must be available to indicate the extent and duration of the undesirable condition and indicate whether a drying-out period is required. In some cases, this may save machine shutdown time. (74) 4-25

The record of temperature and humidity can be used to: (74) 4-25

guidance

- Insure the air-conditioning system continues to perform its job properly. Installation errors and loss of efficiency due to malfunction of some air-conditioning system part can be detected quickly.
- Determine if a mandatory drying-out period is needed when humidity limitations are exceeded. Drying out may be necessary if the excess humidity occurs either during periods of actual operation or while the machine is shut down and unattended. The extent and duration of excessive humidity determines the length of the drying-out period.
- Determine if the environment meets requirements for the machine.

A visual or audible signaling device is desirable in the recording instrument. This is to provide visual or audible indication that temperature or humidity in the computer area is nearing the maximum limit.

Direct-reading instruments with a 7-day electric-drive chart are sometimes used in installations to monitor ambient room conditions. The recorder is usually located at a representative spot in the room and adjacent to the control devices.

For monitoring underfloor air conditions, a remote indicating instrument is recommended. This is usually a 7-day electric-drive chart and can be the wet-and-dry-bulb or electronic type if direct reading is not available. The recording instrument can be located on the wall in the operations room, in the mechanical equipment room, or in any other location convenient to the building engineer.

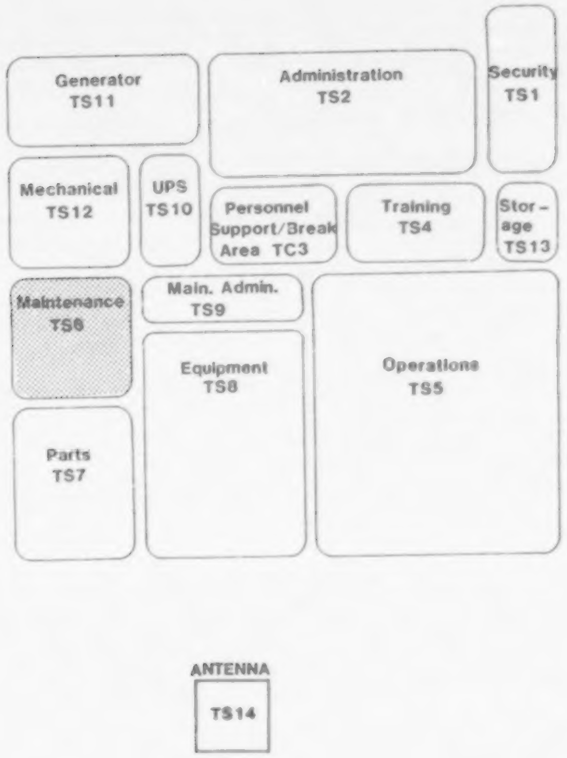
10. Electrical

Consider providing a flexible system that will meet the facility's future requirements. Electronic equipment is constantly being upgraded, modified, and replaced. Bus duct systems and cable trays may prove to be most flexible for areas in which new equipment is expected or that may have frequent modification. (5) 3-4-8. A recommended expansion capacity of 40 percent is usually provided.

Specifically refer to the "Electrical" portion of "Issues and Assumptions" portion of SB2, Vol. 2, for information relative to host nation power requirements. Additional information may be found in "guidance" of SB2 with respect to the standard frequencies and voltage levels used by various nations.

Provide host nation standard outlets if applicable.

MAINTENANCE TS6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Operations
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TS7
ANTENNA
TS14

function

This area is for assigned personnel and the shift supervisor who repair, clean, and test communication equipment.

policy/sop

1. It is desirable to provide a separate maintenance room with space for repair activities and the associated test equipment and tools. The space required will, of course, depend on the amount of C-E equipment installed, the number of maintenance personnel involved, and requirements for stocking spare parts.

2. To test and service a microwave communications system properly, maintenance personnel should have a thorough understanding of the equipment's physical makeup, operational characteristics, capabilities, and limitations, and should be familiar with the circuit theory of operation. It is equally important that the proper test equipment be available to these personnel. As the area of maintenance progresses from onsite field maintenance to depot maintenance, the quantity and requirements of the associated test equipment will increase, necessitating improved facility responsiveness. (70) 7-51

issues and assumptions

activities

1. Inspecting and diagnosing equipment and parts.
2. Completing preventive and unscheduled maintenance.
3. Assembling electronics.
4. Testing electronics.
5. Securing storage of parts and equipment.
6. Maintaining records on parts and equipment.
7. Writing and typing reports, PMI 349's, and equipment historical records.

personnel

1. Shift supervisor
2. One or two Specialists.
3. Contract technician.

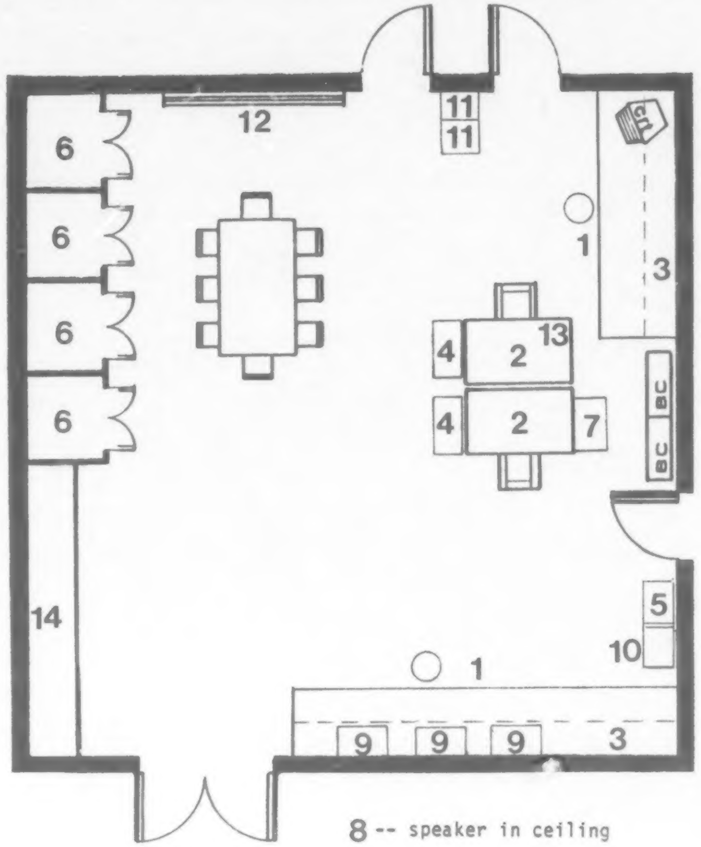
equipment*

1. Two electronic workbenches with stools.
2. Two desks with chairs, one with a typing stand.
3. Shelving over workbench for publications.
4. File cabinet.
5. Portable vacuum cleaner to clean equipment parts. If compressed air blower unit is supplied instead, use 30 pounds per square inch maximum to prevent damage to parts. (Use with a dust collector.)
6. Locked storage cabinets secured to wall for special electronic equipment.
7. Typewriter or word processor.
8. Intercom speaker.
9. Wall-mounted test equipment over workbench.
10. Portable power supply test set.
11. Two scope carts.
12. Multiboard (24 by 48 inches).
13. Telephone.
14. Shelving for inactive equipment storage.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for inspection, disassembly, and reassembly of sensitive electronic equipment. Space must also accommodate administrative, tool, and part needs.	**1.** Provide approximately 500 square feet.	
2. A secure, controlled area.	**2.** The room should be lockable when unstaffed.	**2.** See Vol 2, SB7, Security (Zone 3) for more information.
3. Interior finishes suitable for durability, maintenance, and room function.	**3.** Floor--Vinyl asbestos tile. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	**3.** See also Vol 2, SB2, Interior Construction and Finishes.
4. Acoustical isolation and attenuation to eliminate C-E equipment noise to help personnel concentrate when they work on electronic components.	**4.** The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC. 90, floor surface at NRC .50, and divider partitions (if used) at .85.	
5. Adequate lighting.	**5.** Fixtures should provide 70 footcandles for ambient lighting and 150 footcandles for task lighting.	**5.** For further information on quality of lighting design using the ESI concept, see Vol 2, SB2, Electrical Lighting.
6. Thermal regulation and other comfort features for occupants.	**6.** Regulate temperature at 68°F (heating), 78°F (cooling), with a 5-cubic feet per minute per person outside air ventilation rate. Provide a chair with seat height adustment, casters, swivel, and independent backrest adjustment.	**6.** See Also Vol 2, SB2, Communication Station Buildings--Mechanical.
7. Electrical power.	**7.** Install 120/208 electrical service. 120-volt receptacles should be located for convenience at all workstations and workbenches at the appropriate height for every 10 linear feet of wall. Provide four duplex outlets at each workbench. All equipment and workbenches must be grounded. Frequency levels should be 50 to 60 hertz ± 5 percent.	**7.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
8. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	**8.** Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**8.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance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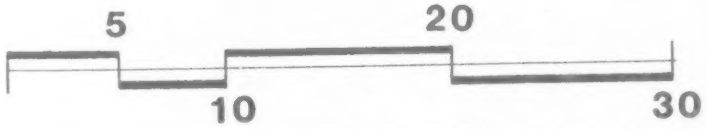
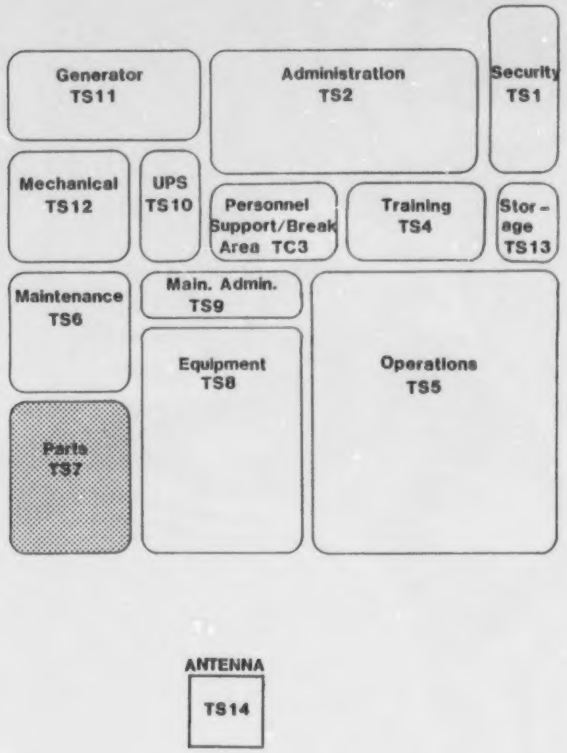
8 -- speaker in ceiling



guidance

PARTS TS7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function

The space required to manage all parts supply operations; ordering, receiving, storage, inventory and security.

policy/sop

1. Requirements for spare parts storage space are determined by the type of equipment within the installation and the level of maintenance to be performed on site.

2. During the course of preventive maintenance inspections, it will be noted from time to time that the performance of some components has deteriorated. Rather than wait for the component to become weaker or to fail completely and cause system interruptions, it is considered good maintenance practice to replace such weak components during the inspection. Although components are replaced before their full service life has been realized, service interruptions can be avoided in this manner. This practice will, in turn, increase the expected replacement parts cost for an operating system; however, the increase is justified on the basis of increased system reliability and the saving of additional manpower costs that would be incurred in making special rush trips to unattended stations to restore station operation. (70) 7-49

best copy available

issues and assumptions

activities

1. Developing parts order lists and working with station Central Supply Office.
2. Receiving, unpacking, shelving of prescribed load list and facility supply parts.
3. Packing and shipping repairable items.

personnel

1. One supply specialist.

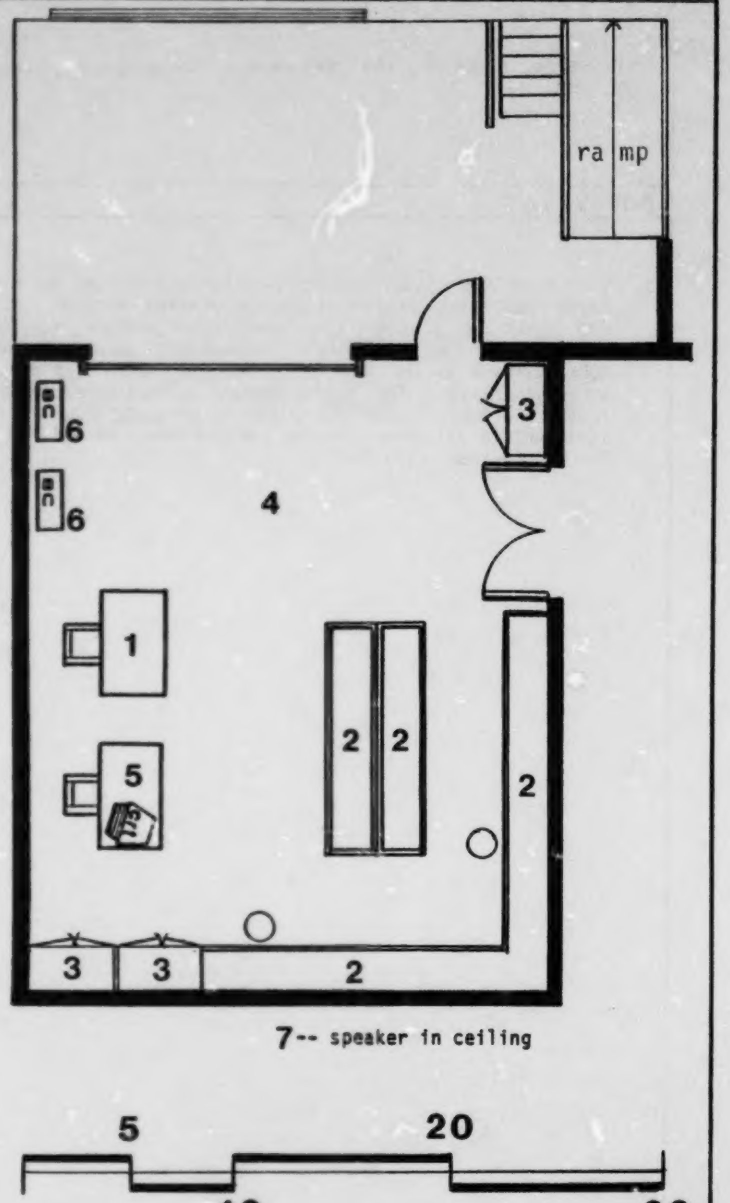
equipment *

1. Table (30 by 60 inches) with chair.
2. Shelving--30 linear feet, floor-to-ceiling type.
3. Three locked cabinets (24 by 36 inches).
4. Open area (100 square feet) for unpacking orders.
5. Desk with chair for parts ordering, microfiche unit.
6. Bookcase for supply manuals--3 to 4 linear feet.
7. Intercom speaker.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for ordering, receiving, and storing C-E equipment. Space must include an open area to facilitate easy receiving of large equipment and supply orders.	1. Provide approximately 1000 square feet to accommodate storage shelves and to leave an open area for receiving shipments of parts and supplies.	
2. A secure environment.	2. This area must be lockable when unstaffed. Provide an intrusion alarm system.	2. See Vol 2, SB7, Security (Zone 3), for more information.
3. Interior finishes suitable for durability, maintenance, and room function.	3. Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	3. See also Vol 2, SB2, Interior Construction and Finishes.
4. Acoustical isolation and attenuation: Acoustical comfort for a nondisruptive environment.	4. Adjacent room walls should limit sound transmission to 40 decibels.	
5. Adequate lighting.	5. Lighting should be: 20 footcandles (ambient) and 70 footcandles (task).	
6. Environmental control for proper storage of electronic equipment.	6. Regulate temperature at 68°F (heating), 78°F (cooling), with a 5-cubic feet per minute per person outside air ventilation rate.	6. See also Vol 2, SB2, Communication Station Buildings--Mechanical.
7. Electrical power.	7. Supply 120/208 electrical service. 120-volt receptacles should be located for convenience at all workstations and workbenches at the appropriate height and for every 10 linear feet of wall. Required frequency levels are 50 to 60 hertz ± 5 percent.	7. See also Vol 2, SB2, Communication Station Buildings--Electrical.
8. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	8. Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	8. See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



7-- speaker in ceiling

guidance

1. Location

Locate the parts area between the exterior receiving dock and the maintenance room.

Provide an open area for unpacking equipment before it is moved into operation or equipment rooms.

A loading dock should be designed for a minimum load of 250 pounds per square foot and should provide enough room to maneuver equipment.

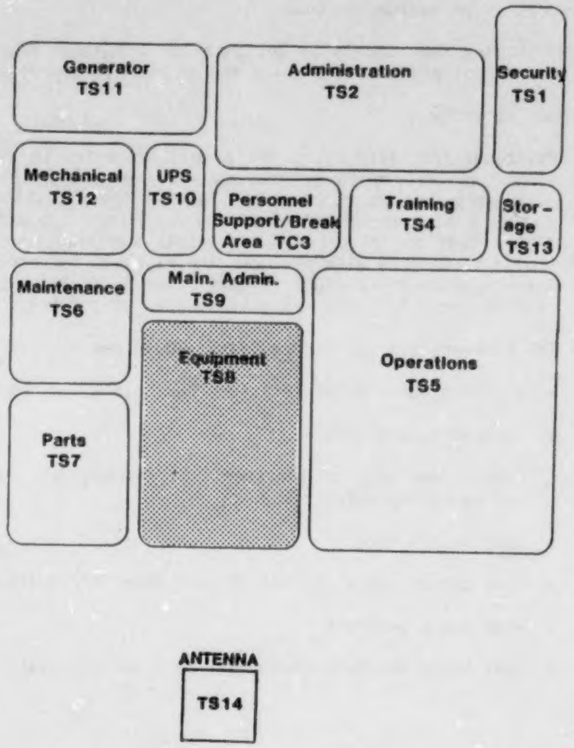
2. Door security

Maintenance/utility doors not permitting entry to administrative/operational spaces should be secured with heavy cylindrical case lock and latch sets in conformance with Federal Specification FF-H-106 and with Builders Hardware Manufacturers Association Standard 601. Doors and hatches that are externally accessible and lead to critical utilities should be secured with padlocks and hasps in conformance with Military Specification MIL-P-43607 instead of or in addition to the cylindrical case or bored locksets specified above. (5) 3-5-9

The hardware set for secure doors should be:

- 1/8-inch-thick drill-resistant hard plate for inside of door
- Secured-type hinges
- Cypher lock with an electronic access control, electric strike, and emergency battery standby
- Combination lock
- Door closer (on each leaf if pair door is required)
- Wide-angle peephole
- Foot bolts and pull-chain bolt for inactive leaf of pair doors.

EQUIPMENT ROOM TS8


Generator TS11
Administration TS2
Security TS1
Mechanical TS12
UPS TS10
Personnel Support/Break Area TC3
Training TS4
Stor-age TS13
Maintenance TS6
Main. Admin. TS9
Equipment TS8
Operations TS5
Parts TS7
ANTENNA
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function

This area contains the mainframes, cryptography, and multiplex equipment.

policy/sop

1. Equipment and layout should be standardized as much as possible among facilities comprising a communications system. In determining the layout for stations with unencrypted signals bearing classified information, the specialized installation guidance found in MIL-HDBK-232(C) must be consulted. Another major consideration is the access necessary for installation, maintenance, and opereation. This would include provisions such as adequate space between rows of equipment to allow for opening cabinet doors or sliding out modules for maintenance. (2) 5-20

issues and assumptions

1. Automated recordkeeping

CRTs with hardline printers can streamline paperwork by storing all circuit history files on disk. This will allow much more rapid troubleshooting inhouse.

2. Electromagnetic compatibility (2) 5-43

Electromagnetic compatibility (EMC) is a complex subject and specialists usually must perform the type of EMC study needed to insure that the equipment or its layout produces no interferences or radiation hazard.

DOD is working on new regulations to specify permissible levels of EM pollution of the frequency spectrum. This effort reflects the concern for environmental protection. Radiation hazards also are being regulated through concern for occupational safety. Engineering agencies involved in military construction must therefore know the legal and regulatory aspects of EMC and radiation hazards to meet the requirements.

Military specifications on EMC, such as MIL-STD-461, -462, and -463 are intended to control and achieve an acceptable figure of merit or quality in the development of new communications equipment. They do not eliminate the need for EMC engineering in facility design. In addition to equipment quality, the frequency selection, nearness to other facilities and, to some extent, facility design itself are variables in the interference generation problem. (2)5-43

3. Determining the correct shielding procedure

A comprehensive approach to shielding equipment from radiofrequency interference (RFI) or TEMPEST involves (a) a building layout to optimize inherent facility shielding conditions, (b) suitable location of all electronic equipment and signal cables, and (c) selection of effective shielding materials and construction components.

See Vol 2, SB4, for additional guidance.

activities

1. Isolating faults.
2. Monitoring and maintaining electronic communication equipment.
3. Receiving and processing outage reports.
4. Typing report logs.
5. Recording maintenance work.

personnel

1. Two shift personnel.

equipment *

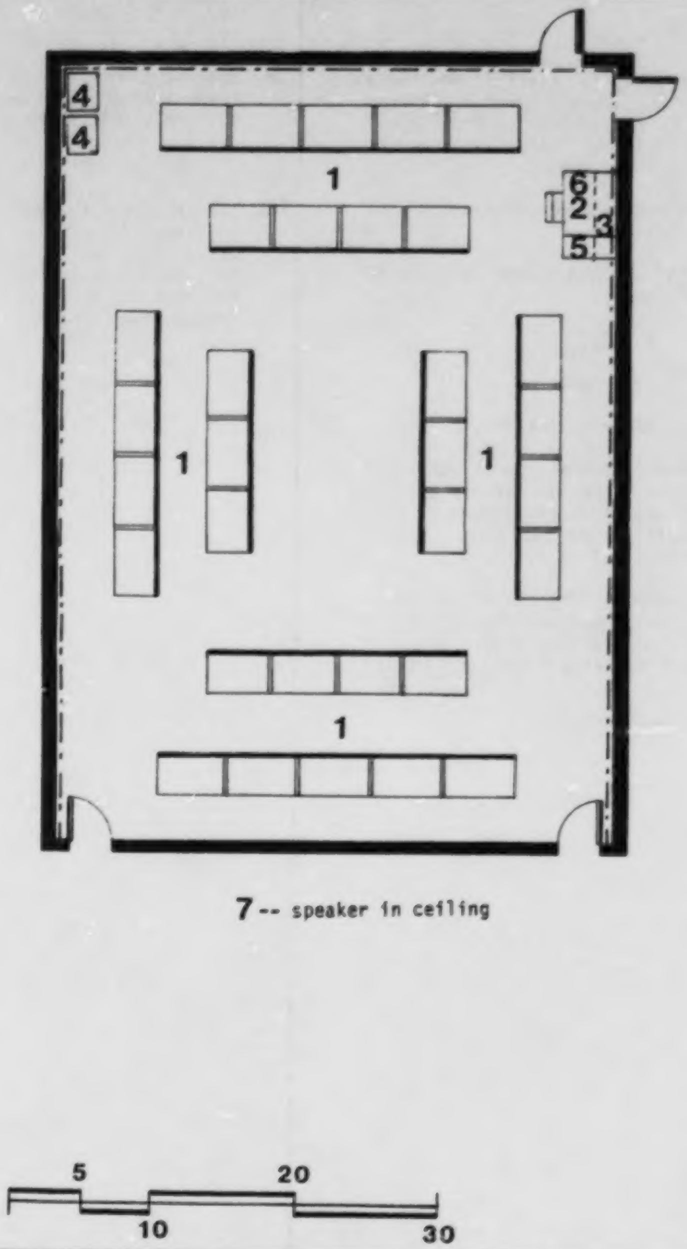
1. Electronic communication equipment.
2. Desk with chair.
3. Bookshelves for manuals (20 linear feet).
4. Carts for equipment.
5. Filesafe with five drawers.
6. Telephone.
7. Intercom speaker.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for transmission equipment layout and to accommodate inspection and testing of communication equipment.	**1.** Space requirement varies with the equipment design. Provide at least a 48-inch workspace behind all equipment for inspection, testing, and repair. See layout in guidance.	
2. RFI shielding.	**2.** Provide shielding in electrical and electronic equipment to prevent interference propagation and to protect the equipment from interference propagated by other electronic devices. (15a) 7	**2.** See Vol 2, SB4, Grounding, Bonding and Shielding.
3. EMP/HEMP shielding.	**3.** Shielding this element for survivability and uninterrupted function during an EM pulse or high altitude pulse. Protective measures are based on intercepting the incident energy and dissipating it or reflecting it away from the threatened device, equipment, or facility.	**3.** See Vol 2, SB5, EMP/HEMP Protection, for more information.
4. Raised floor system.	**4.** Provide raised or false floors for proper cooling of the equipment.	**4.** See also Vol 2, SB2, Communication Station Buildings--Architectural.
5. Interior finishes suitable for durability, maintenance, and room function.	**5.** Floor--Vinyl asbestos tile panels. A raised floor system shall be used over a concrete floor with a dust-on finish with hardener. See Vol 2, SB2, Interior Construction. Base--Glazed structural units, rubber, vinyl or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster and acoustic tiles to within 4 feet of the floor. Ceiling--Acoustic tile.	**5.** See also Vol 2, SB2, Interior Construction and Finishes.
6. Acoustical isolation for variable noise levels produced by electronic equipment.	**6.** Adjacent room walls should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum) and floor surface at .25 (minimum). Acoustic tile is also required to within 4 feet of the floor.	
7. Adequate lighting.	**7.** Ambient lighting--20 footcandles. Task lighting--70 to 100 footcandles for testing and inspection.	**7.** For further information on lighting design quality using the ESI concept, see Vol 2, SB2, Electrical Lighting.
8. Environmental control for proper operation of electronic equipment.	**8.** Provide thermal regulation for 73°F ($\pm 2^{\circ}$) and 50 percent relative humidity ($\pm$ 5 percent). Filtered air must be available in the transmission area. (See MIL-HDBK-411A.)	**8.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.

requirements	criteria	commentary
9. Electrical power.	**9.** Provide 120/208 electrical service. Electric power may fall within the 10,000- to 50,000-watt range. Voltages are required at 50/60 hertz + 5 percent. Provide one 120-volt outlet for every 10 linear feet of wall and as required for coordination with equipment.	**9.** See also Vol 2, SB 2, Communication Station Buildings--Electrical.
10. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**10.** Vaulted enclosure walls--2-hour minimum fire-rated construction; shielded construction. Interior doors in vaulted walls--1.5-hour fire-rated doors; shielded doors and frames. Interior finish--Class A or B only. Automatic fire detection--Local alarm. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility. Manual emergency equipment power shut-off at exits. Under raised floor area automatic fire detection--Local alarm; automatic Halon 1301 suppression system if cross-zoned or matrix detection is required. Sprinkler and Halon systems are not normally installed in the same areas.	**10.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



7 -- speaker in ceiling

guidance

1. Equipment expansion:

It is adviseable to arrange equipment within the equipment room in such a manner that expansion of the building will not necessitate rearrangement of existing installed equipment. (2) 5-21

Approximately three feet of clearance space, at a minimum, should be allowed in front of and to the rear of an equipment bay. If a bay does not permit rear access to equipment, the bay may be installed with no clearance on the back side, i.e.,-against a wall or back-to-back with other bays, ventilation requirements not withstanding. (2) 5-21

4. Raised floor system:

Most all equipment that requires significant cooling to maintain communication operations should be located on a raised floor systems so that maximum use of coupled air directly thru the cabinets is possible. 60°F cooling air supplied directly into the base of the transmitters will leave at the top at approximately 72°F. When the air exits the equipment, it is at a more comfortable temperature for the personnel working in the space.

7. Control Area:

Light fixtures should provide an approximate uniform lighting intensity of 70 fc and be equipped with light control lenses or specular parabolic louvers to minimize glare on working surfaces. The lights over the area where the control console is located shall be provided with a wide-range (100:1) dimming control. (23)12

Equipment Area:

Fixtures should be arranged above the operating aisles running parallel to equipment row arrangement. They should be located so the light does not cast shadows or reflections on the front of the technical equipment, or be obstructed by the cable trays. Flush-mounted flourescent lighting fixtures are recommended, and they shall be equipped with integral RF interference filters (GE no. 89G635, Sprague IF-37, or equivalent). The lights shall not interfere with access to the cable trays or equipment. (23)12 Portable task lighting should also be supplied for the equipment area at 70-100 fc.

8. Protection from moisture migration:

Operating spaces containing electronic equipment usually require close temperature and humidity control. Vapor barriers beneath floor slabs and incorporated into roofing are usually sufficient to prevent moisture migration into and out of interior electronic equipment spaces. Additional protection must be provided where exterior walls form part of the equipment space. (92)12.1-13

See also SB2 - Special Mechanical

guidance

Air-conditioning

Continuous, reliable operation of computer systems depends on an efficient, well designed, properly controlled air-conditioning system. Lack of adequate cooling contributes as much to failure as poorly regulated power. (74) 4-17

Even though certain individual units can operate outside the limits of the overall specifications, the system's environmental requirements are dictated by its most restrictive unit. Computer system requirements are the major considerations in air-conditioning system design. However, good design will also consider personnel comfort. (74) 4-17

An air-conditioning system for a computer installation differs from ordinary comfort air-conditioning in the following ways: (74) 4-17

- Heat dissipation by the computers is relatively constant; therefore, year-round cooling is required.
- The computer room sensible heat ratio is near unity because all heat dissipated by the computer system is sensible.
- Above-average air filtration is required to prevent errors caused by dust particles on magnetic tapes.
- The number of air changes per hour varies between 30 and 60 because of the computer equipment's high heat dissipation.
- Year-round humidity control is required to maintain necessary conditions in the computer room. However, introducing water vapor into the airstream for humidification is not recommended in electronic equipment areas because this can cause damage. (40) 7-3

Temperature and humidity recording instruments

Recording instruments are required to provide a continuous record of temperature and humidity in the machine area. Also, if the air-conditioning requirements are not met, a record is available to indicate the extent and duration of the undesirable condition and to show whether a drying-out period is required. In some cases, this may save machine shutdown time. (74) 4-25

The record of temperature and humidity can be used to: (74) 4-25

- Insure that the air-conditioning installation continues to perform its job properly. Installation errors and loss of efficiency due to malfunction of some air-conditioning system part can be detected quickly.
- Determine if a drying-out period is necessary when humidity limitations are exceeded. Drying-out may be needed if the excess humidity occurs either during actual system operation or when the machine is shut down and unattended. The extent and duration of the excess humidity is used to determine the length of the drying-out period.

guidance

- Determine if the environment in the area meets the requirements for the machine.

A visual or audible signal in the instrument is desirable to indicate when temperature or humidity in the computer area is nearing maximum limit.

Direct-reading instruments with a 7-day electric-drive chart are sometimes used to monitor ambient room conditions in installations. The recorder is usually located at a representative point in the room and adjacent to the control devices.

A remote indicating instrument is recommended for monitoring the underfloor air. This is usually a 7-day electric-drive chart and can be the wet-and-dry bulb or electronic type if direct reading is not available. This instrument can be located on the wall in the room, in the mechanical equipment room, or at any other location convenient to the building engineer.

8. Supply/exhaust system

Air-conditioning input to transmitters is dedicated to each unit. Input is from below, as shown in Figure TS-1. An alternative source of air should also be available.

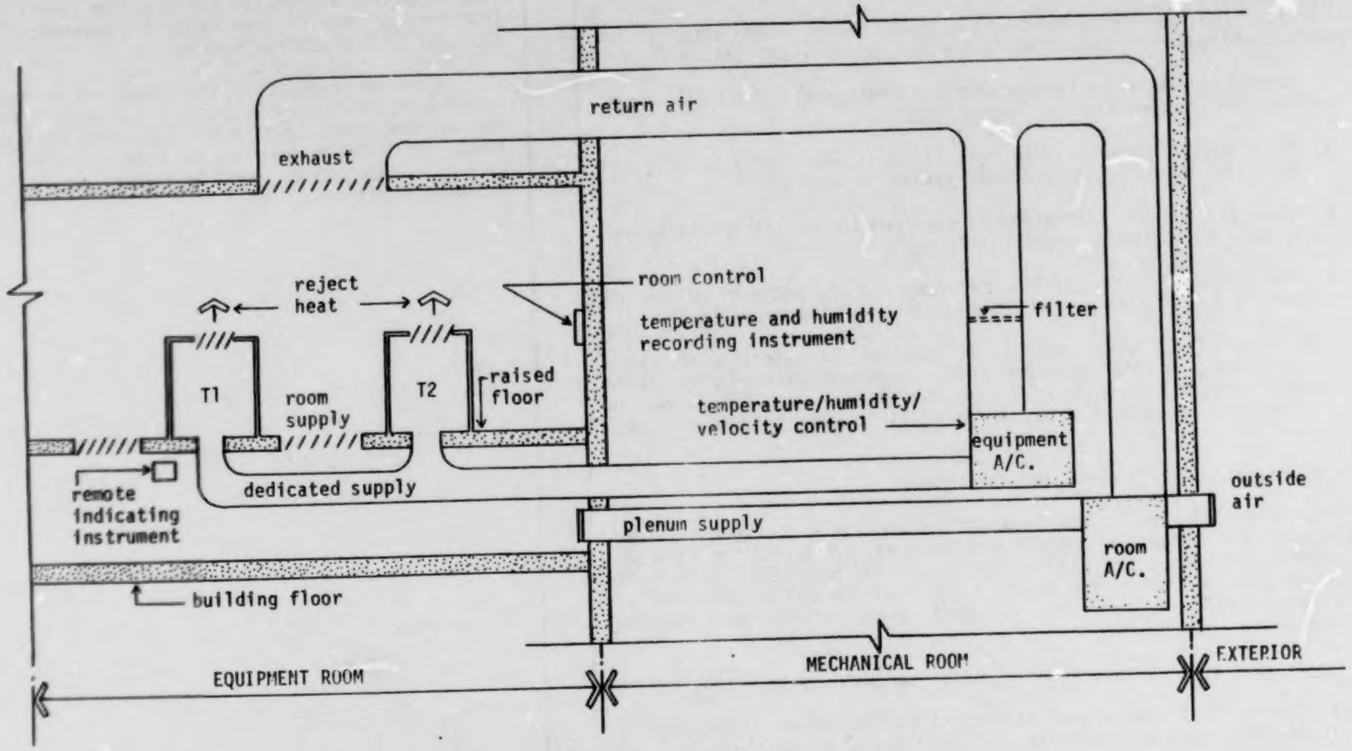
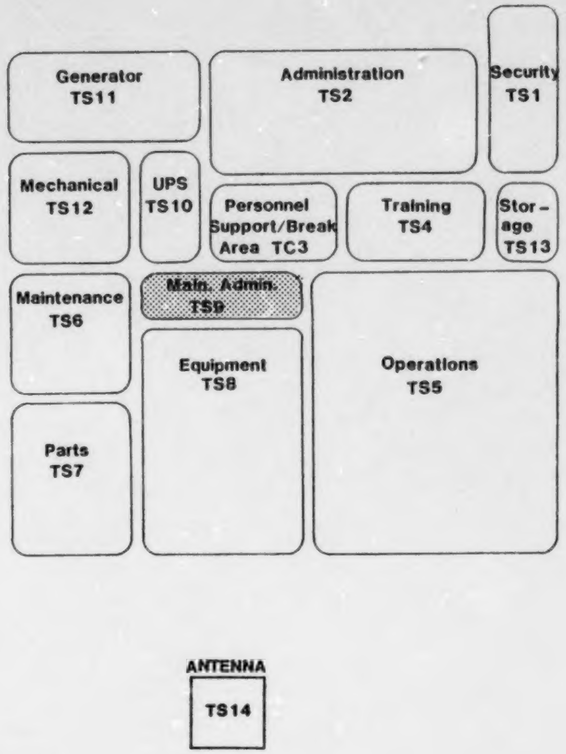

return air
exhaust
reject heat
room control
temperature and humidity recording instrument
filter
T1
room supply
T2
raised floor
temperature/humidity/velocity control
equipment A/C.
remote indicating instrument
dedicated supply
outside air
plenum supply
room A/C.
building floor
EQUIPMENT ROOM
MECHANICAL ROOM
EXTERIOR

FIGURE TS-1. AIR-CONDITIONING INPUT TO TRANSMITTERS.

guidance

guidance

MAINTENANCE ADMINISTRATION TS9


Generator TS11
Administration TS2
Security TS1
Mechanical TS12
UPS TS10
Personnel Support/Break Area TC3
Training TS4
Stor-age TS13
Maintenance TS6
Main. Admin. TS9
Equipment TS8
Operations TS5
Parts TS7
ANTENNA
TS14

function

To provide space that specifically supports the equipment maintenance activities of component trouble analysis and replacement.

policy/sop

1. Maintaining communication equipment requires that specific information be logged into maintenance reports, specifying type of work done, equipment used, equipment history, and parts used (inventory).

issues and assumptions

1. Automated equipment information

Upgrading the system through in-house labor would help develop maintenance personnel responsiveness. CRT's maintenance is a major function at communication facilities; therefore, large quantities of information are generated. An automated records system is needed for:

- Equipment histories (for quality control).
- Automated parts inventory.
- Manuals and specifications.
- Fault isolation for maintenance work by familiarity with the proper procedures.

activities

1. Keeping records of maintenance activity (maintenance logs).
2. Typing.
3. Filing.
4. Specification checking.
5. Parts inventory.
6. Developing maintenance personnel training plans and equipment evaluations.

personnel

1. Maintenance noncommissioned officer in charge (NCOIC).
2. Lead maintenance NCOIC. (where applicable)

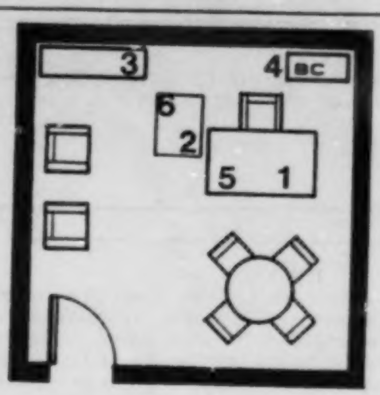
equipment *

1. One desk with chairs.
2. Typewriter/word processor and stand.
3. File cabinet.
4. Shelving for manuals.
5. Telephone.
6. CRT terminal.
7. Intercom speaker.

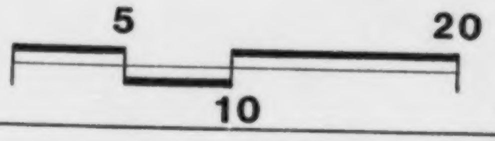
* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate the equipment and furniture associated with the administrative function.	1. Provide 120 square feet of enclosed administrative space.	
2. RFI/EMP/HEMP shielding.	2. The functional relationship of maintenance administration to the operations room may require maintenance administration to be included in the shielded/vaulted area. When this is the case, shielding is required in electrical and electronic equipment to prevent interference propagation and to protect the equipment from the interference propagated by other electronic devices. (15a) 7	2. See Vol 2, SB4, Grounding, Bonding, and Shielding, along with SB5, EMP/HEMP, for more information.
3. Interior finishes suitable for durability, maintenance, and room function.	3. Floor--Vinyl asbestos tile panels. A raised floor system shall be used over a concrete floor with a dusted-on finish that contains a hardener. See Vol 2, SB2, Interior Construction. (Only when included in the vault area.) Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	3. See also Vol 2, SB2, Interior Construction and Finishes.
4. Acoustical isolation and attenuation for a nondisruptive environment.	4. The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .90, floor surface at NRC .50, and divider partitions (if used) at .85.	4. See reference 201, page 3-4, Table 3-2.
5. Adequate lighting.	5. General lighting--20 to 50 footcandles. Task lighting--70 to 150 footcandles, adjustable arms. VDT--5 to 50 footcandles (when applicable). Surface reflectances: Ceiling--80 to 90 percent. Walls--30 to 80 percent (wall at person's back should be 10 to 20 percent). Floor--15 to 40 percent.	5. For further information on lighting design quality using the ESI concept, see Vol 2, SB2, Electrical Lighting.
6. Thermal regulation and other comforts for occupants.	6. Temperature regulation should provide 68°F (heating), 78°F (cooling), with a 5-cubic feet per minute per person outside air ventilation rate. Provide a chair with seat height adjustment, casters, swivel, and independent back rest adjustment.	6. See also Vol 2, SB2, Communication Station Buildings--Mechanical.
7. Electrical power.	7. Install 120/208 electrical service. Receptacles (120-volt) should be located for convenience at each workstation at a suitable height for every 10 linear feet of wall. Electrical power must fall within the 10,000- to 500,000-watt range. Frequency levels must be at 50 to 60 hertz ± 5 percent.	7. See also Vol 2, SB2, Communication Station Buildings--Electrical.

guidance



7 -- speaker in ceiling



guidance

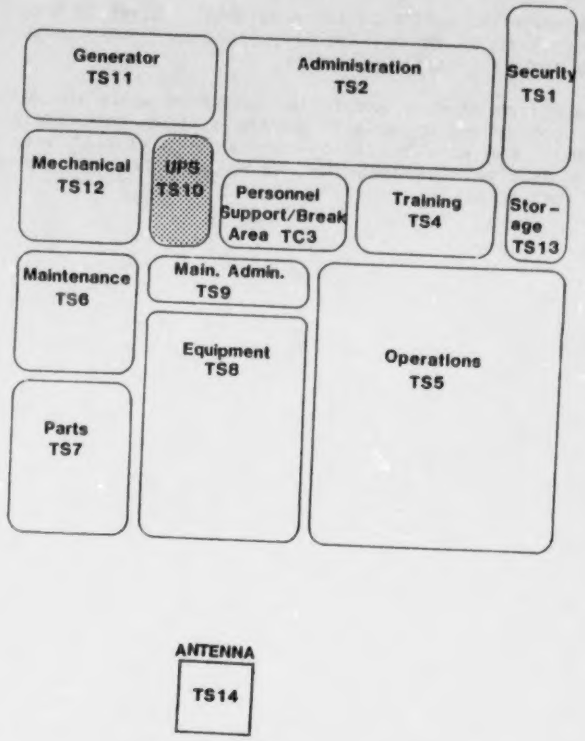
5. Lighting design

To reduce glare at video digital terminals (VDTs), use fluorescent light fixtures with specular parabolic louvers. A louver with cell dimensions of 1.5 by 1.5 inches or smaller will give a high visual comfort probability (VCP) value. A diffuser along with a parabolic louver may also be helpful. Some pigmented acrylic lenses and nonparabolic metal louver panels can also have high VCP values.

The suggested cell size for a parabolic louver is 1 by 1 inch down to .5 by .5 inch. On tall ceilings, the cell depth must be greater; this may dictate a larger cell size.

Glare from windows and reflections from walls and other surfaces must be controlled, especially on the surface immediately behind the VDT. Walls and work surfaces with a matte finish are best. Wall carpeting is also recommended for its noise control and virtual elimination of reflections.

UPS TS10



function

An uninterruptible power supply (UPS) is designed to provide continuous power, without delay or transients, to the critical load.

policy/sop

UPS are characterized by their ability to condition primary or auxiliary power to precise, high-quality power as required by the C-E equipment. UPS maintain continuous power during periods of transfer from one power source to another or for a period long enough to allow for an orderly shutdown. A UPS is required to maintain and provide continuous, conditioned power to the critical C-E equipment and to provide protection from power line transients. The UPS must have the following specific properties.

1. A UPS should serve the critical technical load. It should be solid state with batteries capable of supporting 125 percent of the critical technical load for a minimum of 15 minutes. The UPS is designed to protect equipment from disturbances of voltage and frequency inherent with conventional power distribution systems. The UPS must maintain output voltage and frequency regardless of the nature or severity of the incoming line fluctuations and/or changes in load.
2. The UPS should operate in conjunction with the existing power distribution system to provide quality power for critical technical loads. The system should consist of a solid-state inverter, a battery charger/rectifier, storage batteries, and a static transfer switch with a bypass switch.
3. During normal station operation, the UPS will be supplied with a.c. power by the primary power source; the UPS then changes a.c. power into storable d.c. electrical energy to be used as a short-term, no-break power supply for critical equipment. The UPS uses only a small amount of energy to maintain storage levels. The rest is reconverted into a.c. electrical energy. The UPS' a.c. power input and output are isolated from each other by the energy storage medium. A means should be provided to bypass the UPS completely in the event of failure or maintenance. (1)150 UPS electronic components should be in a room separate from machinery and batteries to prevent their vibration, pollution, overheating, and corrosion. See MIL-HDBK-411A for air-conditioning criteria.

The four common types of installed UPS are:

a. Flywheel--motor-generator.
b. Rotary.
c. Electronic.
d. Hybrid.

policy/sop

4. The power sources and distribution system should be dependable, free from disturbances, and easily maintained. Efficient operation of the earth complex requires a dependable power system that minimizes the number and length of communication outages. Added to the primary objective of dependability are: (a) cost effectiveness to provide the best possible system for the least amount of money and (b) standardization to aid in cost effectiveness, maintainability, and ease of support. Additional information is available in MIL-HDBK 411A AR 420-43, NAVFAC DM-4, NAVFAC DM12.1, AFM 88-15, and the National Electrical Code. (1) 30

5. A modern solid-state UPS is a reliable source of conditioned power. The UPS usually is provided with an electronically controlled static bypass switch when input and output frequencies are identical. The static switch permits automatic bypass if the UPS fails. Also, a manual bypass switch is often provided to permit maintenance on any part of the UPS system. (1) 153 Solid-state UPS have many advantages over mechanical rotary UPS. Bearing, vibration, and low efficiency problems are avoided, and single-point failures are minimized by selection and proper configuration of solid-state UPS. Reserve battery capacity of 15 minutes is normally enough for bringing the UPS online, at which time the auxiliary power plant should be providing the input power. (19) 17

See Vol 2, SB2, for detailed information on UPS.

issues and assumptions

1. Selection of UPS

Single UPS--The single, static UPS has the advantage of simplicity and low cost. The single UPS configuration consists of a rectifier, an inverter, associated controls, protective devices, and an energy storage battery. This system also includes a static bypass circuit that automatically transfers the critical load to the alternate power source without an interruption to the load. When an inverter output failure is sensed, the critical load is transferred to the bypass circuit in less than 5 milliseconds. The synchronous bypass adds about 20 percent to the cost and provides eight to ten times more reliability. UPS failure causes the static switch to transfer the load to the input source, keeping the load online. When selecting this configuration, two conditions must be considered for successful operation: (a) the transfer must be fast enough that the load will not be disconnected and (b) the frequencies and voltages of the primary power and the inverter output must be the same.

Parallel redundant system--This system consists of at least two UPS operating in a load-sharing mode. The output of each is normally connected to the bus through a static interrupter for protection. If an internal fault occurs within an inverter of either system, the static interrupter isolates that inverter from the bus. In case of a bus fault, the interrupter operates in a current limiting mode until the output circuit breaker trips. Parallel UPS may be configured for various combinations of units operating in parallel, such as three units on-line with any two capable of serving the load. Parallel configuration is recommended when the frequency of the primary electric power supply must be converted to serve the critical load such as 50 to 60 hertz.

"Cold" standby independent UPS--This configuration consists of two independent UPS with a common battery. One UPS is online and the other is in "cold" standby. Both UPS are equipped with static bypass circuits that, in the event of UPS failure, automatically transfer the critical load to the primary or auxiliary power source without interruption. The second UPS is then energized manually and placed in the bypass mode and the critical load is assumed by the transfer action of the static switch. The two UPS are not intended to operate in parallel and interlock circuits are provided on the UPS output.

issues and assumptions

2. Float battery systems versus solid-state UPS

The float battery system is the most economical and reliable method of providing continuous d.c. power to critical loads. Since this system is inherently very reliable and since future power sources (renewable energy) provide d.c. power, long-range communications plans call for increased use of d.c.-powered electronics. (19) 10

Floating battery power should be designed for optimal reliability and maximal independence of primary power abnormalities. The battery should be sized to furnish full power to the critical technical load for a period consistent with requirements and system design for auxiliary power capabilities. The battery system supporting solid-state UPS should be sized for 15 minutes in most cases. For 48-volt applications, if specific battery operation requirements are not available, the batteries should be sized for 4-hour operation at attended sites and a minimum of 8 hours' operation at unattended sites. A single float battery system should be designed for all float battery requirements in a common facility. A minimum of two rectifier chargers should be provided. The total number of rectifiers required will be determined by the number needed to supply the load and battery charging current, plus one or more for the maintenance space. When operating on commercial power, the rectifiers should be sized to provide a battery recharge-to-discharge time ratio of not more than 30 to 1. When static inverters are used, provisions should be made to transfer the load gradually from the battery to the primary or auxiliary power source. This provision, normally handled by the rectifier, will minimize transient conditions on the primary or auxiliary power source during the transfer period. (19) 22

activities

1. Doing prescribed maintenance and inspection (PMI) work.
2. Conducting operational checks and load tests.

personnel

1. One, though not located in room continuously.

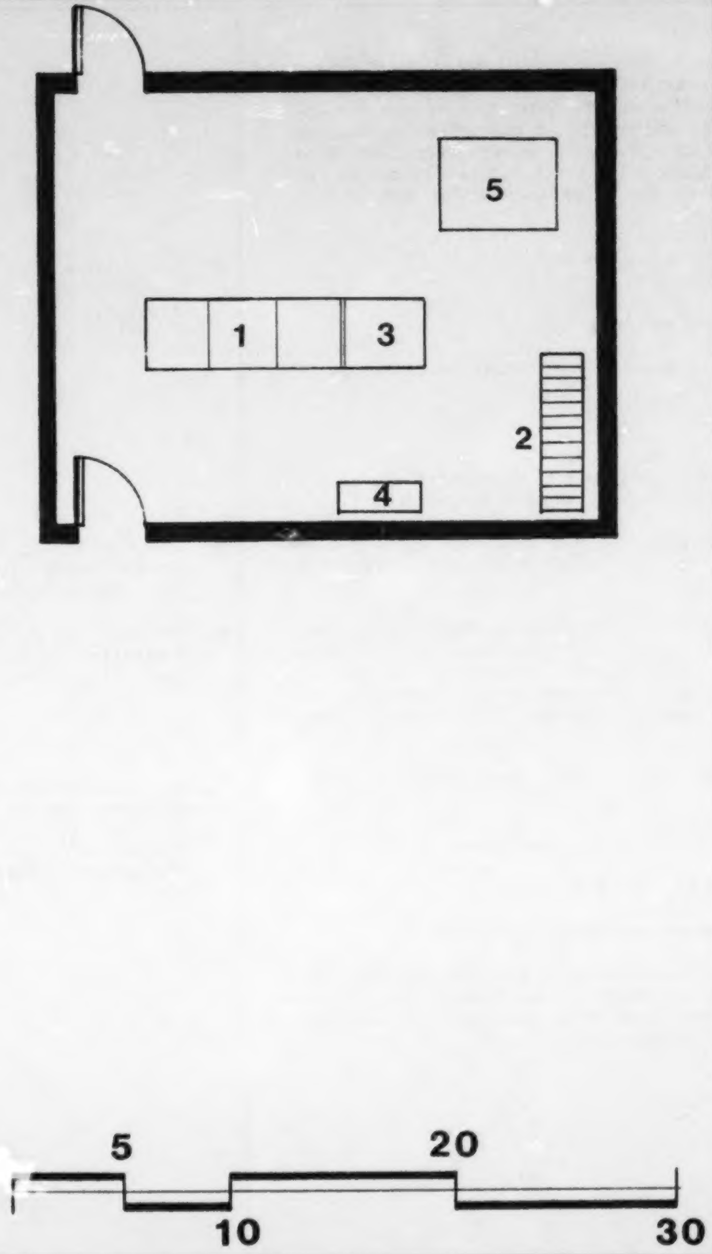
equipment*

1. Solid-state rectifier/charger.
2. Batteries.
3. Inverter, synchronizing equipment.
4. Static switches.
5. Rotary converter (if 60-hertz equipment is used in a 50-hertz host country.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for the operation and monitoring of UPS equipment; proper spacing between equipment for easy maintenance.	**1.** Space needs vary with the communication equipment design (i.e., power requirements), but an average is 400 to 500 square feet. Depending on UPS capacity, certain components are very large and heavy, so consideration must be given to installation and repair or replacement of those items. To accommodate this, knock-out panels may be required. Cable ducts should be located for easy access and drainage.	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation and attenuation for variable noise levels produced by electronic equipment.	**3.** Adjacent room walls should limit sound transmission to 40 decibels.	
4. Adequate lighting.	Provide 20-footcandle (ambient) fluorescent fixtures and 70 footcandles (task) for testing and inspection.	
5. Environmental control for proper operation of electronic equipment.	**5.** Regulate temperature at 50°F for heating. Cooling temperature must be less than 90°F for all solid-state UPS equipment.	**5.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
6. Electrical power.	**6.** Commercial electrical service used in the building will be site-specific. Availability depends on the host country if OCONUS. An outdoor transformer can be installed for UPS spaces in terms of the communication equipment and switchgear. Provide 120-volt receptacles as needed.	**6.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
7. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**7.** Interior enclosure walls--1-hour fire-rated construction. Interior doors--20-minute fire-rated doors. Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**7.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



guidance

1. Location

The UPS and associated battery should be installed in separate rooms. Construction should be permanent type and the wall separating the UPS should be fire-rated (See Vol 2, SB3). Power continuity during emergency periods of power transfer is maintained by an energy storage battery. Reserve battery capacity of 15 minutes normally is enough for bringing the UPS online, during which time the auxiliary power should be providing the input power.

Structural--Minimum floor load is 250 pounds per square foot. A clear ceiling height of 10 feet should be provided.

Doors--All doors to the UPS room should be constructed of steel and should have a minimum dimension of 4.0 by 7.0 feet. Consider installing a louvered bottom door panel on the interior door(s).

5. Environmental control

Consider installing a solid-state UPS in an environmentally controlled room if adverse environmental conditions exist or if recommended by the UPS manufacturer.

guidance

Figures TS-2 and TS-3 show the preferred method of heating and ventilating UPS equipment areas, as well as providing the required ventilation system redundancy. The canopy hood, also called a "receiving hood," should be slightly larger than the equipment or exhaust grills in the cabinets and should extend fairly close to them. Direct connections should be avoided unless specifically recommended by the equipment manufacturer. Each exhaust fan should be sized to handle all the air exhausted through the cabinets plus 10 percent (room air) to insure good capture. (5) 3-3-13.

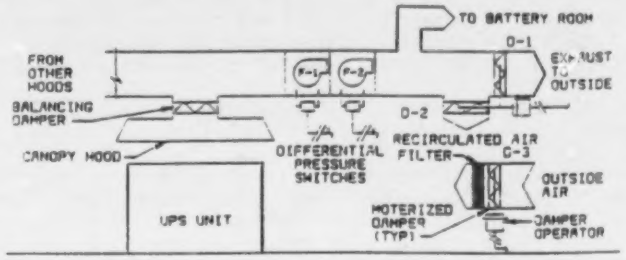

TO BATTERY ROOM
D-1
FROM OTHER HOODS
F-1
F-2
EXHAUST TO OUTSIDE
BALANCING DAMPER
D-2
CANOPY HOOD
DIFFERENTIAL PRESSURE SWITCHES
RECIRCULATED AIR
FILTER
D-3
OUTSIDE AIR
UPS UNIT
MOTERIZED DAMPER (TYP)
DAMPER OPERATOR

FIGURE TS-2. SERIES FAN ARRANGEMENT. (5) 3-3-14

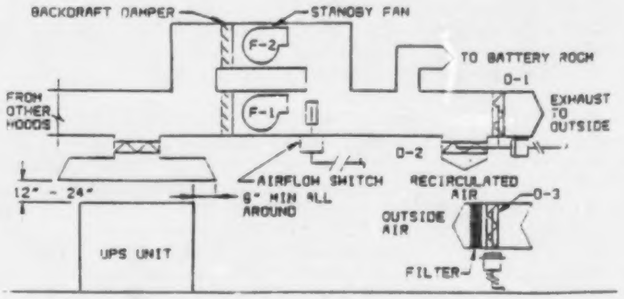
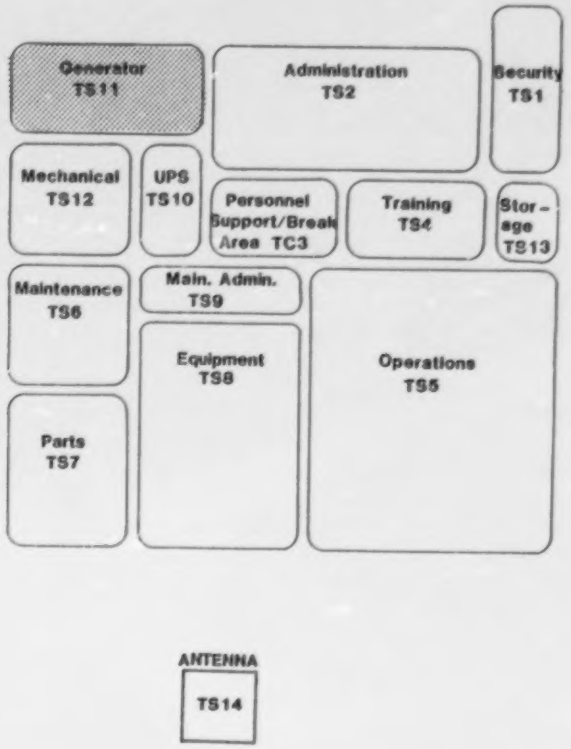

BACKDRAFT DAMPER
STANDBY FAN
F-2
TO BATTERY ROOM
D-1
FROM OTHER HOODS
F-1
EXHAUST TO OUTSIDE
D-2
AIRFLOW SWITCH
RECIRCULATED AIR
D-3
12" - 24"
6" MIN ALL AROUND
OUTSIDE AIR
UPS UNIT
FILTER

FIGURE TS-3. PARALLEL FAN ARRANGEMENT. (5) 3-3-14

guidance

GENERATOR TS11



function

Facility generators maintain power to all communication systems when the commercial power fails.

policy/sop

1. Facilities usually will have three generators as a backup power source in the event of commercial power failure:

   - One generator will be online, set for automatic startup
   - Another will be backup to the first, in case of failure
   - A third generator will be considered "in maintenance" condition to be available if the backup generator fails.

   (See MIL-HDBK 411A for specific policies on the various generator classes.)

2. Primary power requirements for a communications facility are determined by the system configuration and include equipment loads (technical power), utility and domestic loads, and provisions for future expansion. The architectural engineering agency is responsible for designing the site primary power system and its distribution. One of the most economical, convenient sources of auxiliary power is the diesel-engine generator. However, an engine-driven generator requires time to start and warm up, causing a delay before taking the load after a power failure. The recommended practice is to use storage batteries to provide power instantly and economically. They are kept fully charged by the primary power source during normal operation and, when failure occurs, they assume the load instantly without interruption to service. Batteries lack the capacity to supply power for a long period of time, so it is necessary to have an auxiliary generator available. (70) 15-11

3. On-station prime power plants are considered only when the local power is either extremely unreliable or prohibitively expensive, when no power is available, or when self-sufficiency is required for survival and reliability in a wartime environment. On-station prime power plants normally use multiple sets of DOD standard family, diesel-engine generator sets for the power source. Other sources (such as wind turbines, thermoelectric generators, fuel cells, gas-turbine generators, steam-turbine generators, and nonstandard diesel-engine generators) can also be used and should be considered when requirements for a wartime DCS dictate. An onstation prime power plant will use a minimum of three engine generator sets with one set online to carry the station load, one set as a standby, and one set as a maintenance spare. A more reliable configuration is to use four or five generator sets with two online in a load-sharing mode, one as a cold standby unit and one or two as maintenance spares. When the station's standby power requirements exceed 70

policy / sop

percent of the total power requirements and the standby power is redundant, a study should be done in accordance with DOD 4270.1-M to determine if it would be more economical to provide a total energy system that produces both electrical and steam power to be used as needed. (1) 31

4. Site personnel efficiency will be improved if it is possible to locate noisy mechanical equipment, like some diesel generators, away in housing separate from working and living areas or if some other type of noise control is provided. Also, care must be taken to insure that fresh air intakes do not catch fumes or odors from sources such as diesel generators. (2) 5-25

5. All onsite power sources (generators) and substations should be located at a point in the station boundary for which security is adequate. Additional guidelines for locating power sources and substations are: (1) 32

   a. The primary onsite power source should be located far enough from the station work areas to insure acceptable noise levels as outlined by the acoustical noise requirements of MIL-STD-1472.

   b. The primary substation should be located for convenient delivery of power from an off-station source and for easy distribution of the power to onsite facilities as required.

   c. Distribution substations should be located as close as possible to the parts of the operating building they serve.

6. Total fuel storage tank capacity should be determined by local replenishment opportunities, but should hold at least a 30-day supply for primary Class A on-station generators per MIL HDBK 411A. Class C generators require a 7-day minimum supply and Class B generators require a 15-day minimum stored fuel supply. The storage tank(s) should be constructed of fiberglass and when practical, installed underground on an incline to prevent sediment accumulation. Provisions should be made for easy filling and removal of water and other sediment. (19) 13.

issues and assumptions

1. Commercial power versus generators

The mission of DCS communication facilities is to provide reliable communications 24 hours per day. Ideally, the power source for the mission equipment should be reliable, well regulated, easily maintained, and free of transients and disturbances. In actual practice, these desirable characteristics are seldom achieved on a long-term basis. Other factors to be considered in the choice of a facility power supply are:

   a. Providing the best possible system for the least amount of money (cost effectiveness).

   b. Standardizing for better cost effectiveness.

   c. Providing easy support (maintainability). (87) Vol 2, 62

Normally, a DCS communications facility will operate from commercial power using local generators for backup. In some areas of the world, however, commercial power may not be available or if it is, it may be so unreliable as to be unusable for the technical load. Such supplies may be satisfactory for the nontechnical load (area lighting, housing, etc.). In such cases, the primary power source should consist of generators located on the facility site. (87) Vol 2, 83

2. Comparison of engine generators

The selection of an engine generator to supply an independent power source (primary and/or standby) depends on several factors. The choice is usually between a diesel and a gasoline engine. Each has properties that determine its suitability for a particular application.

The diesel engine is suitable for either continuous or part-time service. Initial cost is slightly higher than that of a comparable gasoline engine; for certain applications, however, this disadvantage is more than offset by advantages. The diesel engine is extremely rugged, uses less and lower cost fuel, has a long life expectancy, and offers maximal reliability. Reasons for these advantages include (a) diesel fuel has a higher energy content than gasoline or liquid petroleum, (b) diesel engine operating speed is approximately half that of the gasoline engine, and (c) the diesel engine does not require an electrical ignition system. The last two factors account for lower maintenance and overhaul costs for the diesel engine. Engine starting time is comparable for diesel and gasoline engines.

Gasoline engines can be used for continuous power, but are better suited for standby use. As mentioned previously, the gasoline engine has a lower initial cost, but also a shorter life expectancy. It has a higher operating speed, which wears out the engine more rapidly. It uses more and higher operating speeds, which also wear the engine out more rapidly. It uses more and higher cost fuel and is not as reliable as a diesel engine. One reason for poor reliability is that a gasoline engine uses an electrical ignition system which is subject to failure due to dampness, age, and carbon buildup. (70) 14-3

issues and assumptions

3. Level of maintenance performed

If depot level maintenance is required and authorized, an open area, benches, and special tools (torque wrenches) also are required in the generator room. This is especially true at Navy installations, which require more extensive repair onsite.

4. Above-ground versus below-ground oil storage tank

To insure protection from hostile attack, below-ground tanks provide better security for the standby power system; however, above-ground tanks are cleaned, repaired, and maintained more efficiently, effectively, and economically.

5. Sizing generator fuel tanks

Engine generator size depends on the station's power requirements. The fuel tank capacity for these units depends on the site's accessibility and the size of the engine generators. It should not be necessary to refill fuel tanks more than once a month. If inclement weather or undue hardship dictates a longer period of time between refuelings, a larger tank is recommended. The approximate rate of fuel consumption of a diesel-driven generator, in gallons per hour, can be calculated by multiplying the output in kilowatts by 0.136; this calculation will be helpful in determining the size of tank needed. (70)
14-2

activities

1. Starting the on-line generators after commercial power failure.
2. Repairing and maintaining generators.

personnel

1. Two personnel, though not in room continuously.

equipment**

1. One "set" of generators.* (Usually Class C.)
2. Batteries for start-up.
3. Fuel tank with dispensing pump. (Tank capacity varies with size of generators and reliability level of primary commercial power.)

   See MIL-HDBK 411 for the specific capacity in relationship to a class of generators.
4. Alarm panel.
5. Automatic transfer switches.

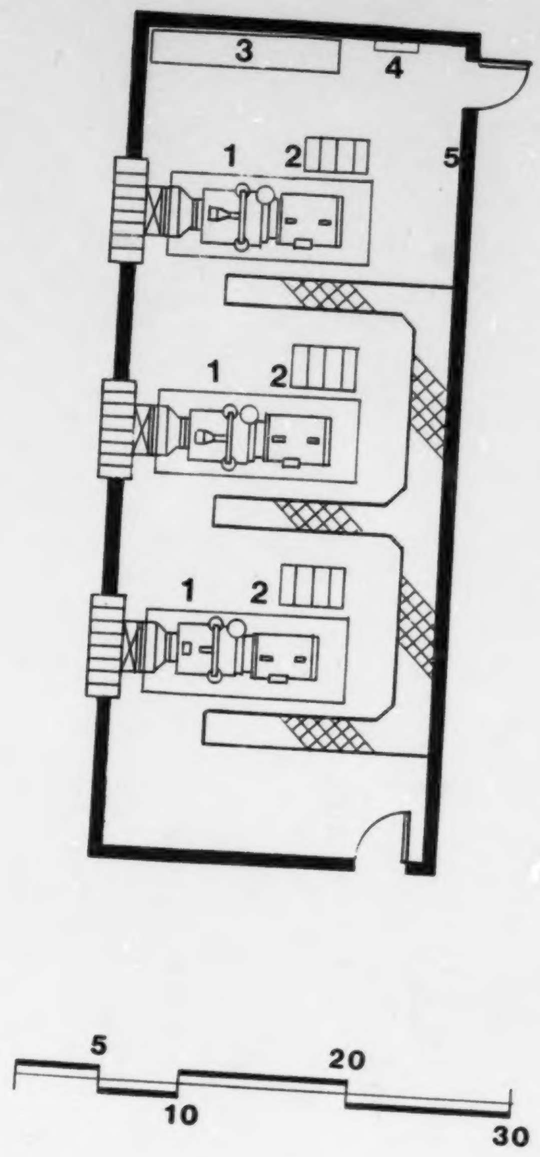
*The number and size of generators will vary among facilities depending on the voltage required to maintain the mission.

** see "guidance" box for example layout of all equipment listed.

	requirements		criteria		commentary
1.	Enough space for the installation, removal, and repair of standby generators.	1.	Space needs vary with power requirements (see guidance drawing). Allow approximately 800 square feet for three generators.		
2.	Interior finishes suitable for durability, maintenance, and room function.	2.	Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	2.	See also Vol 2, SB2, Interior Construction and Finishes.
3.	Acoustic isolation for variable noise levels produced by mechanical equipment.	3.	Adjacent room walls should limit sound transmission to 40 decibels.		
4.	Generator operation indicator and alarms.	4.	An alarm and operation indicator panel will be located at the control console area of the operations space.		
5.	Emergency lighting.	5.	Emergency lighting should be bright enough to allow switch gear operation, instruction reading, and other mission-essential activities.		
6.	Environmental control to provide generators' constant supply of make-up air for combustion and cooling.	6.	Provide automatically adjusted louver units sized for capacity of generator selected. Exhaust stacks must be caged to prevent bird/animal entry.		
7.	Vibration control.	7.	The generators must be placed on a concrete pad physically isolated from the main floor.		
8.	Design that allows complete removal and exchange of generator units.	8.	Air intake/exhaust units should be located and sized to become a "knock-out" panel for removing a complete generator.		
9.	Adequate lighting.	9.	Use 40 footcandles (ambient). "Slow start" fixtures such as mercury vapor should not be used, nor should fluorescent fixtures.		
10.	Thermal comfort.	10.	Regulate temperature at 50°F for heating.	10.	See also Vol 2, SB2, Communication Station Buildings--Mechanical.
11.	Electrical power.	11.	Provide 120/208 electrical service. Install 120-volt outlets; at least two duplex receptacles are required at workbench areas and at the appropriate height. Use 240-volt receptacles when required. Provide host nation standard outlets if applicable.	11.	See also Vol 2, SB2, Communication Station Buildings--Electrical.

requirements	criteria	commentary
12. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**12.** Interior enclosure walls--1-hour fire-rated construction. Interior doors--20-minute fire-rated. Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**12.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



guidance

1. Location

If a standby generator is to operate continuously for instantaneous commercial power backup, the generator room should be located away from all normal operational spaces to isolate the noise.

Clearances--All ducts and other systems installed in the facility as part of the finished structure should be arranged to maintain a 10-foot unobstructed clearance from the floor to the ceiling.

Structural--Isolate the foundations of each generator to prevent transfer of engine vibrations to the building. Floor loading should be designed to accommodate a steady load of the heaviest auxiliary diesel engine generator designed/selected by the contractor. Pad dimensions may exceed the engine dimensions by 25 to 30 percent.

Doors--All single doors should be constructed of steel and should have a minimum dimension of 4.0 by 7.0 feet. The exterior equipment door for the generator room should be double-wing type with minimum dimensions of 6.0 by 7.0 feet. This door should be equipped with a drop-in horizontal bar to secure it from the inside.

Storage tank--When required, provide an underground fuel oil storage tank adjacent to the power/mechanical room. Also provide fuel oil supply and return lines, fill pipe, oil level gage, and alarm conduits. This tank must be equipped with a float switch to activate an alarm indicating a low fuel oil condition.

A single storage tank should be provided for a minimum fuel supply for both the heating boiler and diesel engine generators. MIL HDMB 411A requires Class C generators to reserve a 7-day supply, Class B generators should reserve a 15-day supply, and Class A generators should reserve a 30-day supply. A fiberglass underground tank should be used. A day tank should be provided in the building to supply fuel to both the heating boiler and diesel engine generators. (See also Vol. 2, SB1, Site Planning and Development).

Provide floor trenches in the power/mechanical room for supply and return fuel lines from the exterior fuel oil storage tank and for cable runs from the generator to the transfer switch and main distribution panel. Floor trenches should have 0.25-inch-thick steel plate covers.

guidance

4. Alarm system

Provide a wall-mounted alarm terminal panel in the generator room. The following alarms will be terminated there:

- Generator status
- Commercial power status
- Low fuel oil level (48-hour supply)
- High (80°F) or low (55°F) temperature status in communication equipment and power mechanical room
- Generator start failure.

The termination board or its associated housing should have all alarm terminations identified clearly with permanent marking or labels for future extensions of these connections to a control and fault alarm system. The alarm sensors should incorporate only dry contacts (no voltages) and should use two conductor shielded cables in the circuit runs or in conduit to the consolidated terminal panel noted above.

Provide adequate grounding cable from the building ring ground system, when applicable, to the diesel generator set metal frame and to the underground fuel oil storage tank. See Vol 2, SB4.

6. Environmental control

Generator exhausts should be located such that fumes will not be sucked into other HVAC air intakes. Emergency generators can be located inside the operations building if they are isolated properly from the rest of the structure in terms of fire protection, sound attenuation, and vibration control. (92) 12.1-12

Louvers and Openings

Provide motorized air damper openings in the generator room walls to accommodate diesel engine combustion air requirements. Dampers should automatically activate when generator starts.

Provide security bars on all openings subject to physical intrusion (greater than 7.6 feet in perimeter) such as air intake and exhaust louvers. Their attachment to the structure must be nonremovable from the exterior.

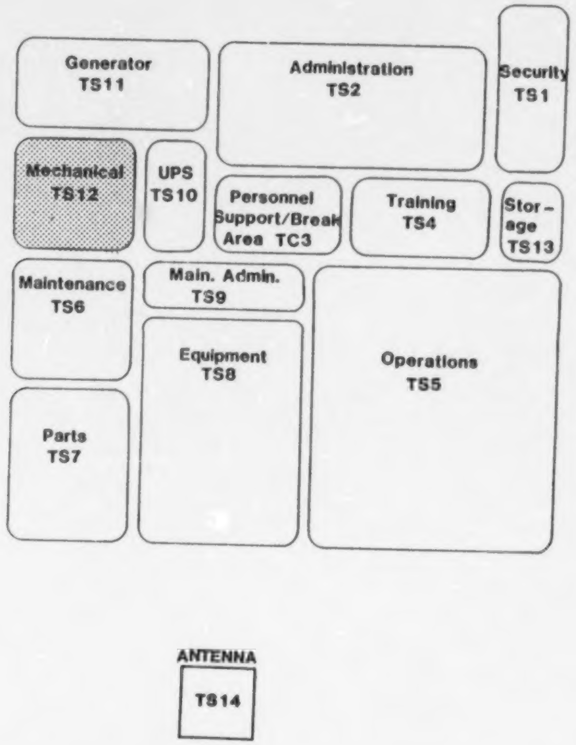
See Vol 2, SB7, for security guidance.

guidance

guidance

guidance

MECHANICAL TS12


Generator
TS11
Administration
TS2
Security
TS1
Mechanical
TS12
UPS
TS10
Personnel
Support/Break
Area TC3
Training
TS4
Stor-
age
TS13
Maintenance
TS6
Main. Admin.
TS9
Equipment
TS8
Operations
TS5
Parts
TS7
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TS14

function

This module provides space for equipment to supply all the heating, ventilating, and air-conditioning (HVAC) and water requirements for the entire facility. It must also be flexible and spacious enough to accommodate alternative energy sources.

policy/sop

1. It is desirable to provide a separate room for mechanical equipment such as heat exchangers, air-conditioners, and waveguide dehydrators-pressurizers. Heat exchangers must have air intake and exhaust ducts to the outside of the building. The size of these ducts dictates that heat exchangers must be located close to the wall. It must not be overlooked that some types of heat exchangers may require rear access for maintenance. Location of the dehydrating-pressurizing equipment is not critical. However, ease of access for maintenance is desirable and the pressure gages should be readily visible to the maintenance personnel. The air-conditioning equipment location will depend on the specific type provided and whether or not intake and outside exhaust are required. (2) 5-24

issues and assumptions

1. Calculation of space requirements

   a. Heating for each area of the facility is commonly provided by an oil-fired hot-water boiler located in the mechanical equipment room. During the heating season, hot water is supplied from the boiler to the various heating, air-conditioning, and domestic hot-water systems. In the summer, domestic hot water is provided by a small oil-fired hot-water heater and the boiler is turned off. This arrangement will add to boiler efficiency and energy conservation.

   b. Provisions will be made in the mechanical equipment rooms to allow for removal of tubes from boilers and chillers as well as the removal of coils and filters from air handling units for maintenance and replacement. All equipment will be located to allow easy access for maintenance and servicing.

   c. Usage will be 24 hours per day, 7 days per week. No special provisions for peak usage are required.

activities

1. Maintaining, controlling, and inspecting mechanical equipment.

personnel

equipment*

1. Chiller.

2. Condenser.

3. Compressor.

4. Water pumps.

5. Boiler.

6. Electrical switchboard.

7. Emergency water supply tank.

8. Day fuel tank.

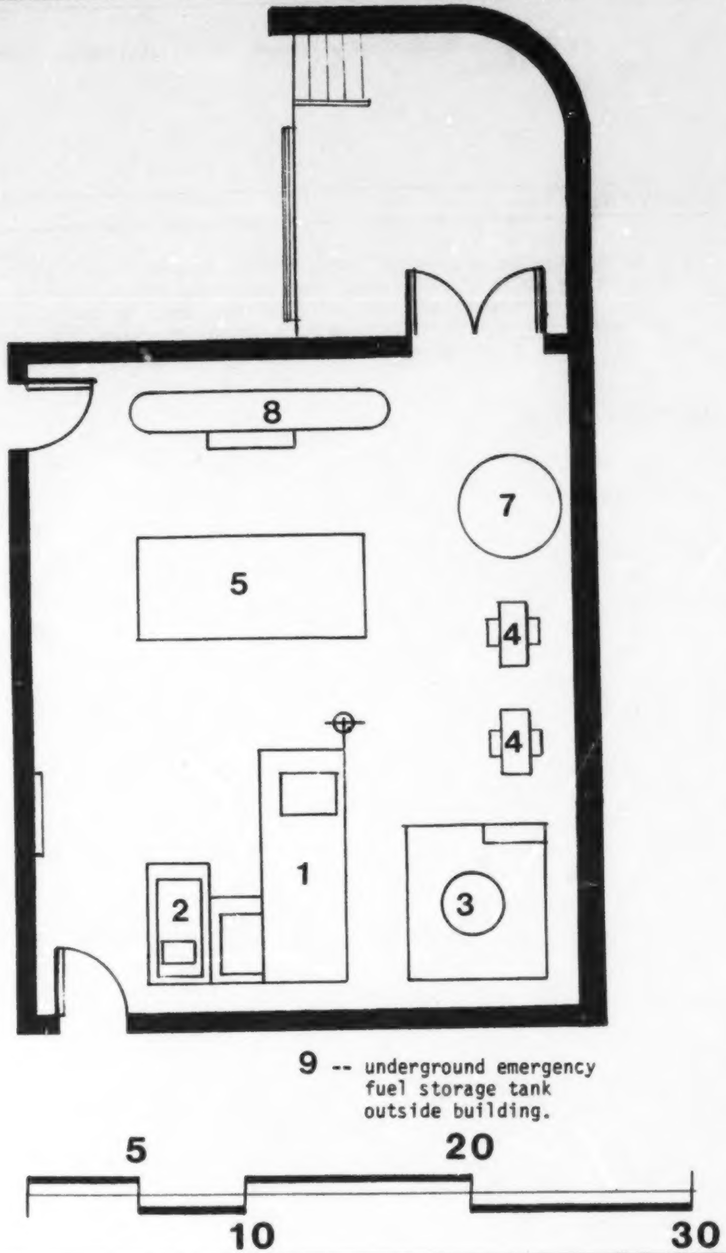
9. Emergency fuel storage tank. (Underground--see Vol 2, SB8.)

Note: Alternative energy sources may vary and alter equipment needs. See Vol 2, SB6--AES, for information.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate the mechanical equipment requirements associated with the facility's environmental maintenance.	**1.** The ratio of mechanical equipment space to the total facility interior floor space varies from 7 percent for small facilities to about 4 percent for large facilities. (See "Issues" box.)	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation for variable noise levels produced by mechanical equipment.	**3.** Adjacent room walls should limit sound transmission to 40 decibels.	
4. Information display.	**4.** The operating instructions, preventive maintenance schedule, wiring and control diagrams, and detailed control sequence should be framed under glass or plastic and posted for easy reference.	
5. Water supply and sanitary sewer.	**5.** The water supply and sanitary sewer for this facility will be connected to the existing post systems or as prescribed for foreign locations. Provide an emergency water supply tank of 20-gallon per capita capacity for 7 days. Water must be refreshed periodically. See Vol 2, SB8, Survivability Protection.	
6. Adequate lighting.	**6.** Provide 40-footcandle fluorescent fixtures (ambient).	
7. Thermal comfort.	**7.** 50 to 68°F range (winter heating), except for batteries, which must be kept at 60 to 68°F.	**7.** See also Vol 2, SB2--Communication Station Buildings--Mechanical.
8. Electrical power.	**8.** Commercial electrical service used in the building will be site-specific. Availability depends on the host country if OCONUS. An outdoor transformer can be installed for the mechanical space in terms of general building power. Install 120-volt receptacles as needed. Electrical power must fall within the 10,000- to 500,000-watt range. Frequency levels should be at 50 to 60 hertz ± 5 percent.	**8.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
9. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**9.** Interior enclosure walls--1-hour fire-rated construction. Interior doors--20-minute fire-rated. Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**9.** See Standardized Modules--Building Design Principles, Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



9 -- underground emergency fuel storage tank outside building.

guidance

1. Storage tank

A single storage tank should be provided for a minimum 15-day supply for both the heating boiler and diesel engine generators. A fiberglass underground tank should be used. A day tank should be provided in the building to supply fuel to both the heating boiler and diesel engine generators. This tank must be equipped with a float switch to activate an alarm indicating a low fuel oil condition.

Doors--The exterior equipment doors should be steel, double swing type with steel frame. The inner opening should be at minimum 6 feet wide by 7 feet high. The equipment door should be equipped with interior locking panic hardware.

Both the exterior personnel and equipment door hinges must be welded to prevent removal of hinge pins if pivots and pins are on the outside.

Provide security bars on all openings greater than 7.6 feet at the perimeter and subject to physical intrusion (for example, air intake and exhaust louvers). Their attachment to the structure must be nonremovable from the exterior. See Vol 2, SB7, for additional security guidance.

Structural--The minimum floor design load is 150 pounds per square foot. A clear ceiling height of 10 feet should be provided.

Mechanical equipment should be isolated to minimize vibrations. This can be done by mechanically isolating each individual system on concrete pads separate from the mechanical room floor.

Heat exchangers must be provided with air intake and exhaust ducts to the outside of the building. The size of these ducts means the heat exchangers must be located close to the wall. However, some types of heat exchangers require rear access for maintenance. Location of dehydration pressurization equipment is not critical, but ease of access for maintenance is desirable. Pressure gages should be readily visible to maintenance personnel. Location of the air-conditioning equipment depends on the specific type provided and whether intake and exhaust to the building's outside are required. (2) 5-25
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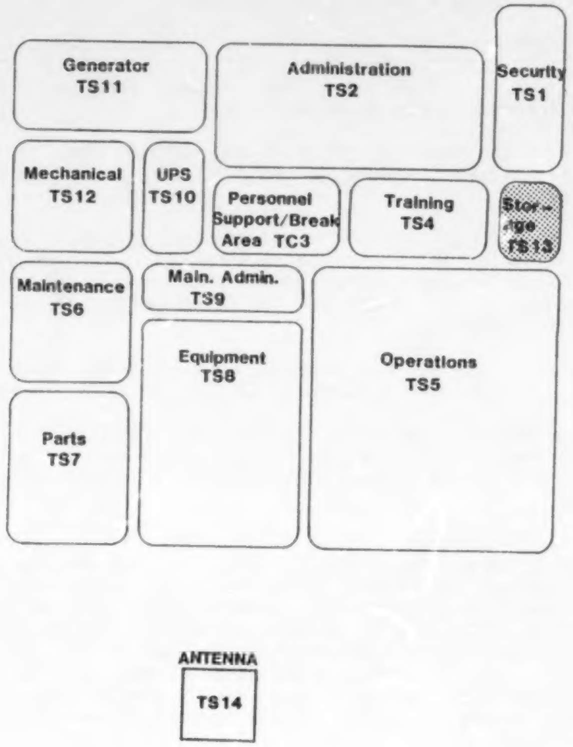
STORAGE TS13


Generator TS11
Administration TS2
Security TS1
Mechanical TS12
UPS TS10
Personnel Support/Break Area TC3
Training TS4
Stor-age TS13
Maintenance TS6
Main. Admin. TS9
Equipment TS8
Operations TS5
Parts TS7
ANTENNA
TS14

function

This area is for the temporary placement of miscellaneous items and nontechnical equipment.

policy/sop

1. All services have physical fitness requirements that must be met. For remote DCS facilities that have no installation services available, it is recommended that exercise equipment be made available. The exacting, sometimes intense, activities of maintaining and controlling the DCS require periodic breaks for physical exercises.

issues and assumptions

1. Storage for exercise equipment

The exercise equipment should not conflict with the function of other personnel-oriented rooms. A general purpose storage room is suitable since the equipment is unofficial.

activities

1. Shelving of miscellaneous sized items.
2. Individual exercise.

personnel

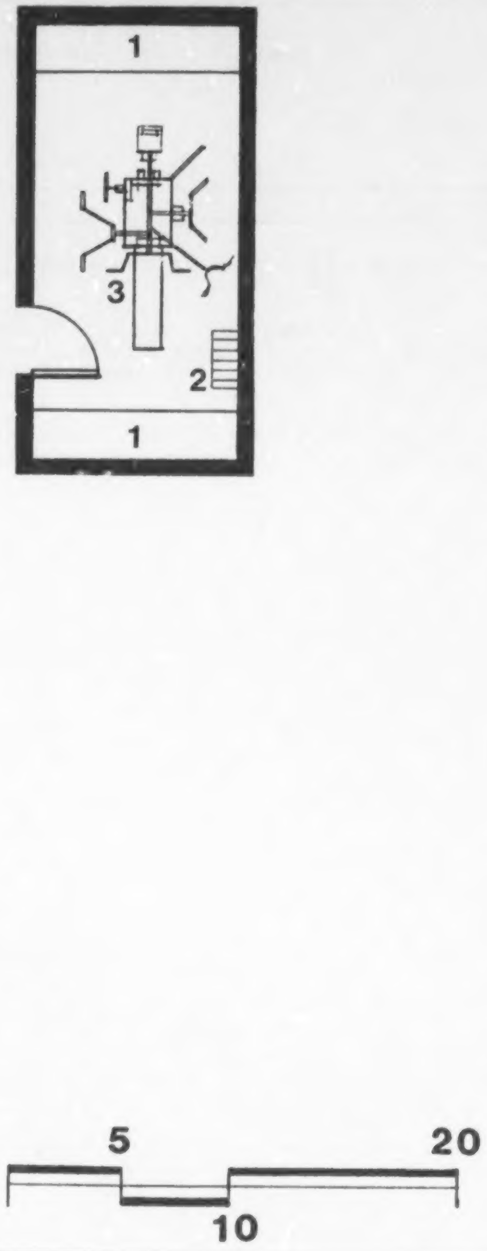
equipment *

1. Shelving 18 inches deep.
2. Small step ladder.
3. Exercycle, universal gym, and/or loose weights.

* see "guidance" box for example layout of all equipment listed.

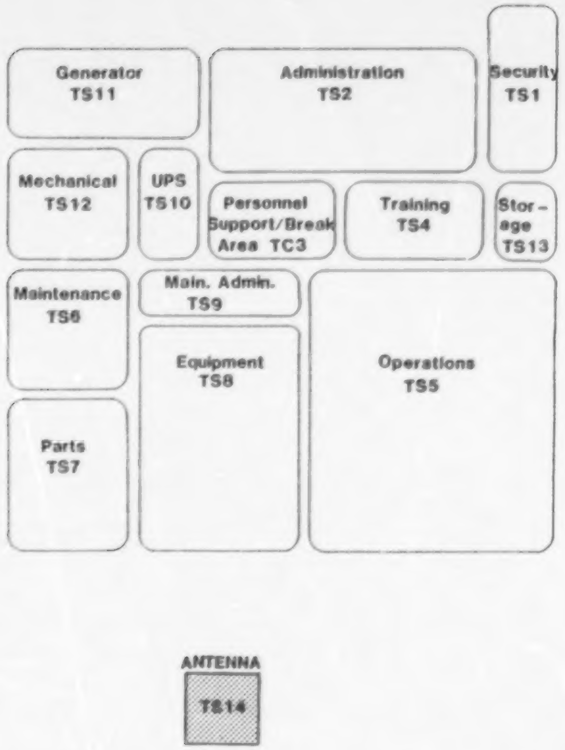
requirements	criteria	commentary
1. Enough space to accommodate two or three persons exercising, plus space to move about for shelving items.	1. Allow approximately 250 square feet to accommodate the exercise equipment plus 60 linear feet of shelf space.	
2. Interior finishes suitable for durability, maintenance, and room function.	2. Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	2. See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation and attenuation for a nondisruptive environment.	3. Adjacent room walls should limit sound transmission to 40 decibels.	
4. Adequate lighting.	4. Use 30-footcandle (ambient) fluorescent fixtures.	
5. Thermal comfort.	5. Regulate temperature at 68°F (heating), 78°F (cooling). Provide 10 cubic feet per minute per person outside air ventilation rate with on-off switching.	5. See also Vol 2, SB2, Communication Station Buildings--Mechanical.
6. Electrical power.	6. Install 120/208 electrical service. Provide 120-volt outlets--one receptacle for every 10 linear feet of wall. Frequency levels should be at 50 to 60 hertz ± 5 percent.	6. See also Vol 2, SB2, Communication Station Buildings--Electrical.
7. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	7. Interior finish--Class A or B only. Corridor finish--Class A only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	7. See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



guidance

ANTENNA TOWER TS14


Generator
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TS6
Main. Admin.
TS9
Equipment
TS8
Operations
TS5
Parts
TS7
ANTENNA
TS14

function

The purpose of this element is to support antennas and transmission lines adequately.

policy/sop

1. Lightning protection must be considered as part of each tower installation. (3)5-39
2. The antenna structures should be placed as close as possible to the equipment building, consistent with design codes and standards, to minimize the transmission line lengths required between equipment and antennas. (3)5-6
3. All towers shall provide suitable climbing facilities to the top, including access to any beacons or antennas mounted there. (70) 15-29

issues and assumptions

1. Self-supporting versus guyed towers

Microwave towers can be either self-supporting or guyed. For permanent installations and main-route, high-density use, self-supporting towers are preferred. They require less real estate than the same height guyed tower and offer more flexibility in locating the antennas, which provides for possible future antenna relocation. For temporary or tactical use, guyed towers may be more practical. The real estate required for tower guys is somewhat variable, but usually does not exceed a circle with radius equal to the tower height. Towers can be designed for almost any height; however, economical and practical considerations limit the maximal height to approximately 300 feet for wideband communications. This is not an absolute maximum, but alternatives should be carefully considered if higher towers seem to be required.

2. Parameters for tower and foundation design

Tower and foundation design depend on four main factors: (1) soil bearing capability at the specific location; (2) size and number of the parabolic antennas and their location on the tower; (3) expected meteorological conditions; and (4) the maximal tower twist and deflection that can be tolerated under worst conditions of wind loading (and ice loading if that applies). The required tower foundation design is directly related to the tower design and the specific soil conditions involved. (3)5-34

3. Tower height

The most common and important construction limitation is tower height. Towers exceeding a given height may violate local ordinances for several reasons. For example, if a link will be near an airport or in established air corridors, the site proposed may not be approved if high towers are required. Similar restrictions may apply in or near residential areas or in certain scenic areas. A very remote site may involve special construction restrictions if access roads will not permit heavy equipment (e.g., cranes) to reach the site. Certain types of construction materials may be unavailable or too expensive in some areas; in addition, special types of construction may be necessary because of local climatic conditions (as in the arctic), extremely wet regions, or in regions subject to earthquakes. (3)4-8

Except for overwater paths, a tradeoff often can be considered between high towers on a long path and an additional active or passive repeater site. This may require input from the field survey. (3)4-72

4. Tower safety

Tower safety must be insured for: (1) personnel using the structure and (2) aircraft. (3)5-38

The safety features required to protect personnel when working on the tower must be included in the tower design. Design requirements for ladders, stairs, and elevated work platforms are specified in OSHA, Volume 1, General Industry Standards. Requirements for ladder climbing safety devices are stated in AFM 127-101 and OSHA, Volume 1, General Industry Standards. (3)5-38

issues and assumptions

The hazard imposed to aircraft by the tower is minimized in two ways: (1) painting and lighting and (2) restriction against tower installation. Restriction against installation is covered by AFM 86-8, Airfield Clearance Criteria. For installation in a foreign country, the siting engineer must check for clear zone or height restrictions that may exceed those in AFM 86-8. (3)9-38

5. Antenna uses

Parabolic antennas are especially economical, combining small weight and small space requirements with low costs. Their side- and back-lobe attenuation is adequate for low-capacity systems and for single broadband radio-relay links. (3)4-188

Shell and horn-reflector antennas are more expensive, but offer a more favorable radiation pattern. Therefore, they are used mainly in broadband systems on links with many parallel RF channels and at junction stations to prevent mutual interference. (3)4-188

6. Tower material

In general, a hot-dipped galvanized-steel tower is the most desirable support for an antenna or plane reflector. This type of tower is easily shipped in sections 10 or 20 feet long, is durable, can be easily climbed, and can be procured to meet the exact height requirements. (70) 15-19

requirements	criteria
1. Mechanical stability for antennas.	**1.** To obtain the reliability required for the communication system, the structure supporting the antenna must have long-term mechanical stability compatible with the antenna's beam characteristics. (See Guidance.) (2) 4-220
2. Lightning protection.	**2.** Lightning protection for towers should be in accordance with the latest edition of Underwriters Lab (UL) Pamphlet 96A, Lightning Protection Systems. (2) 5-34
3. Painting and lighting.	**3.** To prevent hazards to air commerce, antenna towers and similar structures must be marked in a way that makes them conspicuous when viewed from aircraft.
4. Radiation protection.	**4.** A potential radiation hazard exists in systems that radiate electromagnetic energy at an intensity high enough to injure personnel or that create an environment unsafe for fuel or explosives. High-voltage equipment may constitute an additional hazard in the form of ionizing (X-ray) radiations. (2) 5-44
5. Transmission line selection and protection.	**5.** Transmission lines for troposcatter and diffraction links usually will be waveguides. However, on lower frequency tropocatter links, waveguides would be large and cumbersome, so coaxial cable is used on all low-power connections, such as that between the receiver and duplexer. (2) 5-35
6. Avoidance of frequency selective fading.	**6.** Avoidance depends on the quality of transmission line installation, prevention of beam intersections, and shielding from other sources.

guidance

1. Antenna mechanical stability

The structures involved in maintaining this mechanical stability are the antenna mount and/or tower. The strength and cost of mounts and towers needed to supply the required resistance to deformation will depend on the wind velocities and ice loading characteristics of the area at which the antennas are being installed. The requirements for vertical angular stability are somewhat more stringent than for horizontal stability since, in addition to mechanical deformation, the vertical angle of arrival is also a function of atmospheric stratification. (2) 4-221

Antennas can have two possible types of unwanted mechanical displacement: elastic, such as torsional vibration and sway, and inelastic resulting from, for example, backlash in antenna mounts, changes in guy wire stress, foundation settling or the bending of structural members. The limit of elastic change in horizontal antenna orientation for an antenna mounted at the tower's top should be less than ±0.2 of a degree 99 percent of the time. The estimate of wind loading forces should be based on the time distribution of estimated wind velocities for the geographic area in which the antennas will be mounted and on the antenna aperture area. It is important to consider peak wind gusts rather than average wind velocities; also, wind velocities on high terrain or mountain peaks tend to be considerably higher than on adjacent lowlands, where climatological stations are located most frequently. (2) 4-221

Limits for horizontal inelastic movement of the tower and antenna mount should be such that the antenna's horizontal orientation will change no more than ±0.1 degree during its operational life. Even this amount of change may not be allowable for the system as a whole, since other mechanical considerations may necessitate a tighter tolerance. (2) 4-221

The tower and mount should be stiff enough that wind and ice loading do not change the antenna's vertical orientation at the top of the tower (1) elastically more than ±0.1 degree more than one percent of the time or (2) inelastically more than ±0.1 degree during the tower's operational life. (2) 4-222

Towers generally are designed for a wind load of 30 pounds per square foot of flat surface without ice coatings. For areas subject to tornadoes or hurricanes, or for which ice loads may be excessive, heavier towers are necessary. (70) 15-20

A tower's loading is the resultant of all forces acting on it. The tower design must be such that, with all antennas and other required items mounted on the tower, it will resist any deflection or twisting beyond a specified amount when subjected to maximum specified wind and ice conditions. (3) 5-34

Since the net result of all forces on the tower are also, in effect, transmitted to the foundation, the foundation must be able to distribute the force over a large enough area and depth so as not to exceed the soil bearing pressure at any point. It also must resist movement in any direction.

guidance

The foundation's height above ground will depend on groundwater conditions, but should never be less than 6 inches. In warm climates where frost is not a problem, the foundation depth will depend only on tower load and soil bearing characteristics; in colder climates, the foundation must be extended below the frost line or to firm ground. (70) 15-20; (3) 5-34

The communications engineer must the supply following type of information for the tower designer to design a suitable tower and foundation: (3) 5-35

- Size and type of antennas required and type of radomes.
- Azimuth and elevation angles for each antenna.
- Amount of adjustment required for alignment after installation.
- Height above ground for each antenna.
- Location of tower with respect to the buildings and their corresponding orientations.
- Antenna beam widths and tower twist and deflection that can be tolerated under maximum expected wind and ice loading.
- Required type and number of waveguide runs and power cabling for feedhorn or radome heaters.
- Required tower lighting, obstruction lights, lightning protection grounding systems, and paint.
- Required platforms to allow access to the antennas for maintenance and/or alignment.
- Required means of access up the tower, including required personnel safety features.
- Provisions for future antenna requirements.
- Climatic details of the area involved.
- Local restrictions and/or other constraints that may be involved.
- Soil conditions.

For systems using directly beamed paraboloids without plane reflectors, the deflection tolerance can be reduced to the same value as the twist tolerance. In general, towers designed to meet required wind- and ice-load specifications are rigid enough to meet twist and deflection tolerances. (70) 15-22

guidance

A fixed-base, self-supporting steel antenna tower will be used in the Digital European Backbone (DEB) to support the microwave antennas when a concrete tower is not required. The tower contains an internal access ladder and rest platform landings with attached safety rails, navigational hazard lights with photoelectric control, cables and conduit, and lightning protection equipment, including air terminals, ground rods, straps, and cables. The tower also includes the antenna mounting assemblies that consist of the support framing and a 4-inch vertical pipe routed 18 inches from the face to the tower. The tower is designed to support its own dead load as well as those from the antennas and integral mounting assemblies, 2 inches of radial ice with an applied load of 125 miles per hour wind acting simultaneously, ladders, platform landings, cable ladder tray and waveguide, and a live load of 100 pounds per square foot on the platform landing. (88) Q-1

2. Lightning protection

Lightning protection must be considered as part of each tower installation. Tower grounding procedures establish an electrical connection between the tower and the earth to provide proper lightning protection. For directly beamed paraboloidal antenna systems, the waveguide path down the tower cannot be considered a reliable path to ground. Steel tower installations should be protected by a low-resistance ground connection at the tower base. When wooden poles are used for towers, copper wire should be connected from the top of the pole to a low-resistance ground arrangement at the pole's base. The steel tower should be grounded in the following way: install ground rods on opposite sides of each tower foundation at a distance no greater than 12 inches from the foundation. Use 5/8-inch-diameter ground rods, or equivalent, and drive them into the ground no less than 8 feet. Bond each leg or tower's common base to the ground rods using No. 6 AWG or larger copper wire. With the same size wire, connect the tower ground system to the station ground system. Install ground rod in the same way at each concrete guy anchor; the metal part of the guy anchor should be bonded to the ground rod. When steel or other metallic anchors are in direct contact with the earth, no additional ground rods are required. (70) 15-23

All equipment mounted on a tower shall be fastened so that it is effectively grounded through the tower. On structures provided with obstruction lights, it may be desirable to place suitable lightning arresters on the wires supplying these lights, at least between the lower part of the tower and the power supply source and, in some cases, at the top of the tower as well. (70) 15-24

As a general rule, the maximum permissible resistance between any two ground rods before connection to the tower is 2 ohms. If the resistance between rods is found to be greater than 2 ohms, it will be necessary to increase the soil conductivity. One method of lowering the resistance path between ground rods is as follows: dig a tapered trench around each ground rod. (The trench should be approximately 2 feet deep, with a bottom radius of 1 foot and top radius of 2 feet.) Then place approximately 40 pounds of rock salt in the trench and backfill it. (70) 15-24

guidance

Note: Antenna and building counterpoises must be connected in accordance with MIL-HDBK 419.

3. Tower painting and lighting

The guidelines and requirements contained in this section apply mainly to installations within the United States. At overseas installations, regulations imposed by cognizant military and/or government agencies must be studied. To prevent hazards to aircraft, antenna towers and similar structures must be marked to be conspicuous when viewed from the air. The type of marking to be used depends in part on the structure's height, location with respect to other nearby objects, and nearness to aircraft traffic routes near landing areas. Requirements and specifications for marking potential hazards to air navigation have been established through joint cooperation of the FAA, FCC, DOD, and appropriate branches of the broadcasting and aviation industries. Specifications determined by these groups aid in the final decision as to whether a structure constitutes an obstruction to air navigation. When conducting the preliminary site survey, it is advisable to determine the prevailing ordinances concerning such structures, and perhaps to discuss them with local government and building authorities. When dealing with locations within the continental United States (CONUS), the latest copies of Government Rules and Regulations, FCC Form 715, FCC Rule, Part 17, and FAA Standards for Marking and Lighting Obstructions to Air Navigation, with all revisions, should be consulted. These rules not only apply to specifications for antenna structures, but also describe the forms that must be submitted to FCC, FAA, and the U.S. Coast and Geodetic Survey (FCC Form 401A Revised, FAA Form 117, FAA Form ACA-114, and C&GS Form 844). (3) 5-40

To warn airmen about obstructions during daylight hours in good weather, all structures that may present a hazard to aircraft will be painted from top to bottom in accordance with requirements of the latest edition of FAA-AC 70/7460-1. (3) 5-41

FCC and FAA lighting specifications are given in terms of antenna structure heights. The requirements for towers and obstructions will be determined from FAA specifications in the latest edition of AC 70/7460-1. The specifications further stipulate that placement of the lights on square or rectangular towers shall be such that at least one top or side light is visible from any angle of approach. When a flashing beam is required, it shall be equipped with a mechanism that can produce no more than 40 nor less than 12 flashes per minute with a period of darkness equal to one-half the luminous period. (3) 5-41

When the tower structure is under construction, FCC and FAA require that temporary lights, consisting of at least two 100-watt lamps enclosed in aviation red globes, to be displayed at the top of the structure from sunset to sunrise. Lights must also be installed at intermediate heights if FAA requirements specify. (3) 5-42

FCC requires tower lighting to be exhibited from sunset to sunrise unless otherwise specified. At unattended microwave installations, a dependable automatic obstruction lighting control device must be provided. A light-sensitive control device will be used to control obstruction lighting when manual control is not possible. This requirement will be met in microwave installations by using a tower lighting

guidance

kit. These kits apply power to the lights when the north skylight intensity is less than approximately 35 footcandles and disconnect the power when the north skylight intensity is greater than approximately 58 footcandles. (3) 5-42

To insure the proper operation of tower lights, FCC specifies that the lights must be inspected at least once every 24 hours; the inspection can be performed either by direct observation or by observing an automatic, properly maintained indicator designed to register a lights failure. When obstruction lighting is not readily accessible for periodic inspection, the rules permit use of electric signaling devices to indicate lamp failure. Should the fault alarm system register a failure in obstruction or beacon lighting, the failure must be reported to the nearest FAA Airways Communication Station. The FAA must be notified of any code beacon, rotating beacon, or top light failure if not corrected within 30 minutes after failure. (3) 5-42

4. Tower height

Additional important questions to be considered are the type of tower that would be allowed at the site, possible hazards to aircraft, space needed, soil conditions suitable to support the required tower, and the wind and ice loading conditions. (3) 4-71

Both guyed and self-supporting tower types can be used to support the antenna or plane reflector in heights up to several hundred feet. In general, it is not economically advisable to go above 300 feet because of the rapidly increasing cost of suitable towers. (70) 15-19

For lower tower height requirements (30 to 60 feet), wooden poles of good quality, properly preserved, can be used if they are available in the required lengths. Guying arrangements should be considered to obtain the required rigidity. It is often necessary to use H-frames or other special construction techniques to attain this rigidity. (70) 15-19 In calculating tower heights, the minimum antenna height above ground should be at least 12 feet to maintain clearance of security fences, vehicles, and personnel. If sites with suitable elevations are not available or if the path is partially obstructed, clearance is obtained by increasing the antenna tower's height at one or both sites. In determining optimal antenna heights and, thus, tower height, several factors are important for systematic analysis: (3) 4-122

- Terrain clearance required for the particular path.
- Effect on atmospheric penetration angle.
- Cost.
- Antenna height requirement for adjacent paths with antenna located on the same tower.
- Limitations because of local ordinances.
- Logistics.

See MIL-HDBK-416. section 4.4.4 for more information.

guidance

5. Transmission lines

The three waveguide types common in LOS applications are:

- Rectangular.
- Circular.
- Elliptical.

Each type has certain advantages and disadvantages both from technical and economic aspects. The choice will therefore depend on the specific use and must be determined by the design engineer with consideration given to all factors involved. (3) 5-49

One disadvantage of rectangular waveguide is the many joints required in a complete run, with each joint a potential trouble point. Another disadvantage is that it will only accommodate one polarization, so in cases for which dual polarized antennas are to be used, it will be necessary to have two complete waveguide runs to the antenna. (3) 5-49

The two major advantages for circular waveguide are its low attenuation (approximately half that of rectangular or elliptical) and its ability to support two polarizations on a single waveguide run. These advantages can be of great benefit in high-capacity systems using dual polarization or when high towers are required with consequent long waveguide runs. Another desirable property is the relatively low return loss. The disadvantages are that it is essentially useful only for straight runs, requires great care in handling and installation, and demands considerably more expertise in adjusting for minimum loss and maximum polarization isolation. (3) 5-49

The advantages for elliptical waveguide are its availability in almost any continuous length and its semiflexibility. It thus offers the possibility for a long, continuous run without joints except at the two ends. Its attenuation is approximately the same as equivalent rectangular waveguide. The main disadvantages are the comparatively large bending radius required, the skill required to properly attach elliptical-to-rectangular transitions normally required at each end, and the restriction of only one polarization. Waveguide runs should be kept as short and direct as practical to minimize line loss. (3) 5-50

Other items such as circulators, isolators, filters, duplexers, and diplexers may be required in various combinations and are essentially a part of the overall waveguide system; however, one or more may also be supplied as an integral part of the radio. If any of these items are required outside the radio equipment, consideration must be given to their placement and mounting to keep the waveguide run as short and direct as possible and to minimize the need for bends and twists. (3) 5-53

All external waveguide runs should be pressurized with dry air or an inert gas. While standard tanks of nitrogen may be used for this purpose, automatic dehydrator-pressurization equipment is generally preferred. The pressure should not exceed the manufacturer's recommenda-

guidance

tion for the particular waveguide involved. This is generally on the order of 2 to 10 pounds per square inch gage. Pressure windows are available to isolate pressurized from unpressurized parts of the waveguide. (3) 5-53

The compressor-dehydrator (air dryer) provides low-pressure dehydrated air to the waveguide. The air dryer is a semiportable, electric unit that works on the principle of compression and absorption. The unit consists of a motor-driven, oilless air compressor, an air tank assembly, a self-reactivating dehydrator, a moisture trap, a pressure switch, and the gages and controls necessary to insure the delivery of dry air at the proper pressure. (88) H-1

6. Selective interference

Undesired signals radiating from transmitters on the same or adjacent frequencies to the one desired are potentially major sources of interference. These sources include satellites, satellite ground stations, radar stations, and other microwave relay systems in the same area. In addition, reflections from aircraft and precipitation act as secondary sources. Since aircraft and precipitation both move with respect to the terminals, they cause selective fading and therefore distort the wanted signal. Above 10 gigahertz, unwanted signals reflected from rain can be especially troublesome because there is a high probability that the wanted signals will be attenuated at the same time the undesired signal is reflected into the receiving antenna. Quantitative information for estimating the outages caused by these various sources often are impractical to obtain, but the following should be considered when designing a particular link: (3) 4-186

- Avoid main beam intersections with undesired sources.
- Site shielding may be effective when a site must be shared with a source of unwanted signal. Shielding can be done by advantageous location on the brow of a hill, antenna placement at a location at which the unwanted source is screened by evergreens, or by an actual cut made in a hill.
- Transmission line connections, cable, and component shielding must be designed to prevent radiation leakage. Mechanical RF switches, shutters, and probes must be avoided or, when they are necessary, must be designed carefully to prevent radiation or the picking up of unwanted signals.

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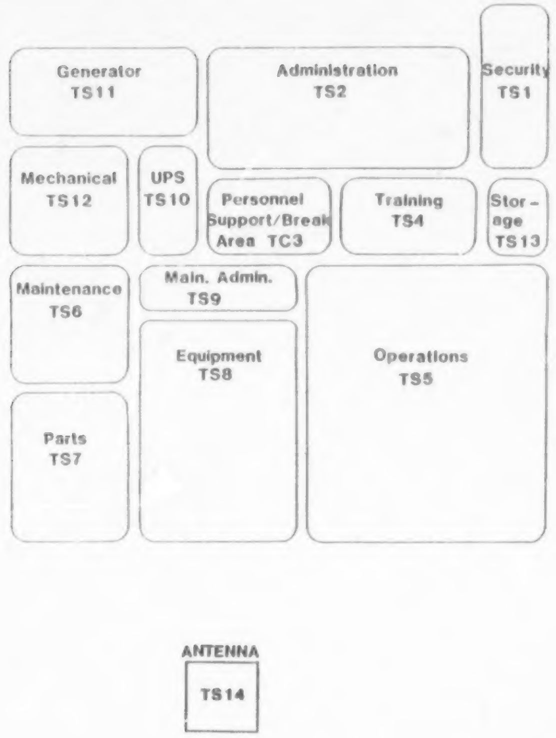
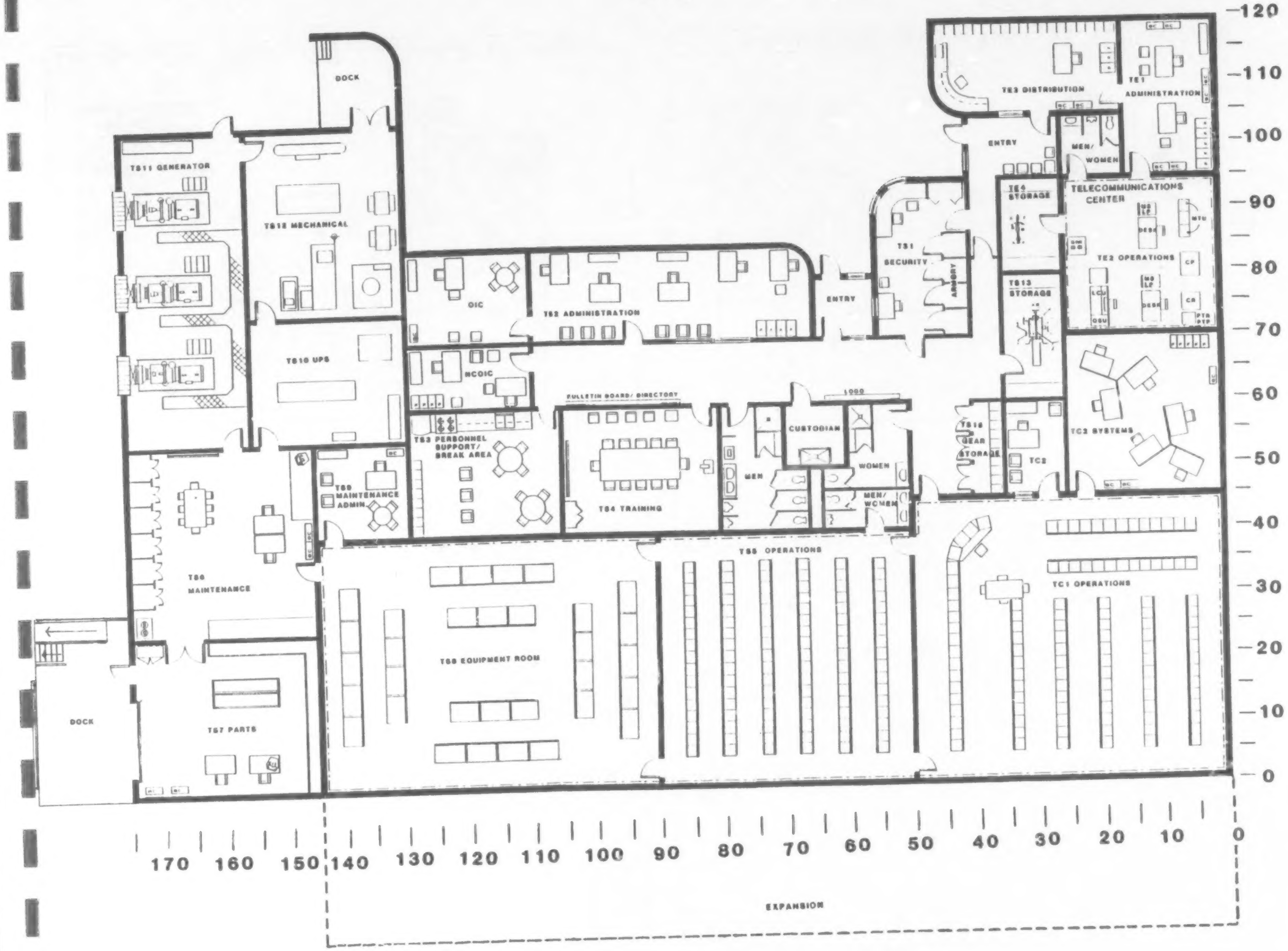
STANDARDIZED MODULES TS15



building design principles

1. Efficiency of operational functions
   - a. Communication equipment aligned for surveillance and access.
   - b. On-the-job training with operating equipment.
   - c. Interaction of operational support activities.
   - d. Accessibility of toilets for operations personnel.
2. Integration of parts/maintenance modules with operations
   - a. Parts/maintenance modules contiguous with operations spaces.
   - b. Loading dock accessibility for equipment and supplies.
3. Efficiency and accessibility of administration spaces
   - a. Administration transition space between public areas and secure spaces.
   - b. Efficiency of integrated administrative spaces.
4. Personnel support spaces
   - a. Change of environment for on-duty personnel.
   - b. Facilities available for physical training.
5. Integration of power/UPS modules
   - a. Economies and efficiencies of integrated power modules.
   - b. Minimized impact of generators on communications transmissions.
6. Facility expansion
   - a. Expansion potential in new construction operations space.
   - b. Minimized impact of future operations space expansion.
7. Security operation
   - a. Location of security space to control building access.
   - b. Central monitoring of total site and building security.
   - c. Message security in operations and cryptography modules.
   - d. Limited access into secure areas.
8. Facility security/survivability
   - a. Required vault construction for communication system equipment.
   - b. Protection of the communication signal.
9. Fire protection
   - a. Fire protection classifications: occupancy, hazard of contents, sprinkler protection, and construction/materials.
   - b. Building separation distances.
   - c. Fire protection systems: automatic fire suppression, automatic notification/alarm, and automatic fire detection.
10. Life Safety
    - a. Occupant load determination.
    - b. Protected exit conditions: exit capacities, number of exits, exit travel distances, and means of exit arrangement.
    - c. Allowable interior finishes.
    - d. Egress path identification: illumination of means of egress, emergency lighting, and means of egress marking.


DOCK
TS11 GENERATOR
TS12 MECHANICAL
TS10 UPS
OIC
TS2 ADMINISTRATION
NCOIC
ENTRY
TS1 SECURITY
ARMORY
TE3 DISTRIBUTION
TE1 ADMINISTRATION
ENTRY
MEN/ WOMEN
TE4 STORAGE
TELECOMMUNICATIONS CENTER
TE2 OPERATIONS
TS13 STORAGE
TC3 SYSTEMS
TC2
TS16 GEAR STORAGE
BULLETIN BOARD/ DIRECTORY
1000
CUSTODIAN
MEN
WOMEN
MEN/ WOMEN
TS3 PERSONNEL SUPPORT/ BREAK AREA
TS9 MAINTENANCE ADMIN
TS4 TRAINING
TS6 MAINTENANCE
TS5 OPERATIONS
TC1 OPERATIONS
TS8 EQUIPMENT ROOM
DOCK
TS7 PARTS
EXPANSION
120
110
100
90
80
70
60
50
40
30
20
10
0
170
160
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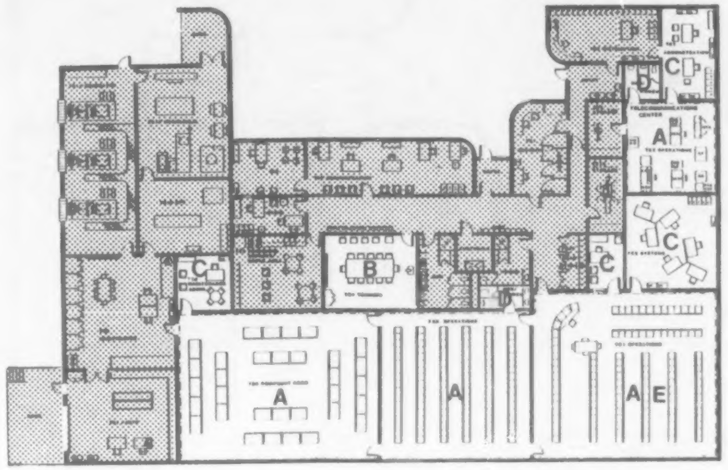
guidance 1. Efficiency of Operational Functions



A. Equipment should be aligned in parallel rows within the operations modules for ease in visual surveillance and to provide direct access to all critical equipment. Multiple consoles should be adjacent to each other so that limited personnel can monitor them efficiently at one central location. Tables for audiovisual training aids should be available in operations modules so that personnel can train on-the-job during regular watch periods.

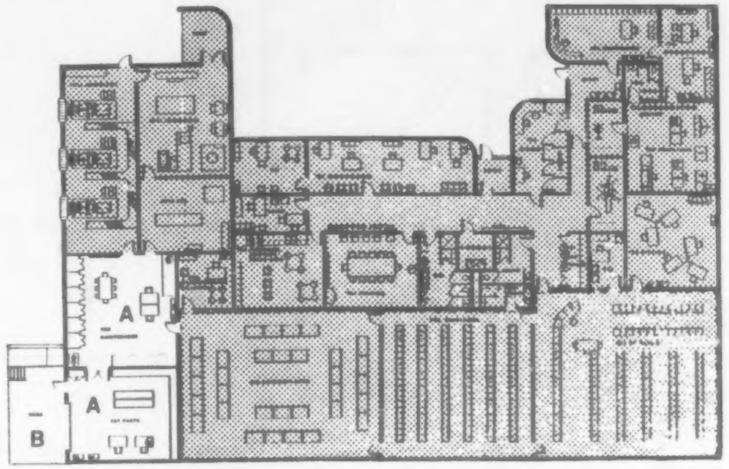
B. To further enhance the effectiveness of on-the-job training, instruction can be done in small groups of four or five in a training room for hands-on experience with communications equipment. This requires a close relationship with the operations module.

C. Additional building modules with a close functional relationship to operations activities should be located adjacent to the operations module.

D. Toilet facilities should be nearby for personnel in the operations module.

E. See technical control module information in section TC, Vol 1B.

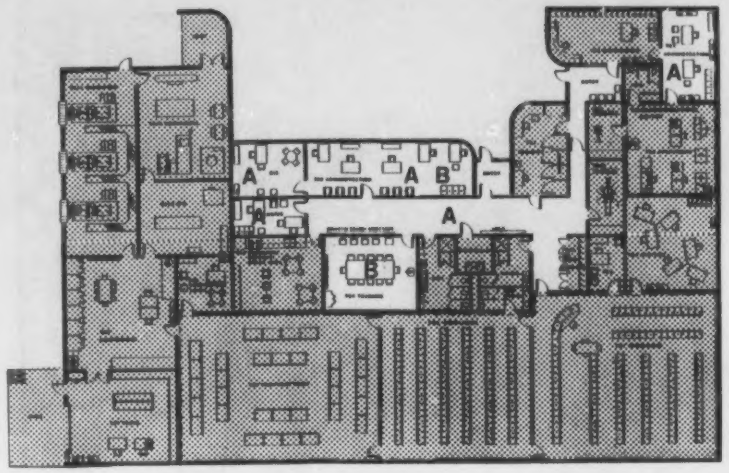
guidance 2. Integration of Parts/Maint. Modules with Ops.



A. Parts and maintenance modules should be well integrated and contiguous with the operations spaces to optimize efficiency and minimize circulation. The secure door between the operations and the maintenance/parts spaces is used only as a fire exit and to bring communication equipment in from and out to the loading dock. This door should have opening hardware only on the secure side.

B. Parts and maintenance from modules must be located within an organizational context such that deliveries can be made to the total building in a direct and secure process at a loading dock. The large communication equipment can be moved in and out more easily using the loading dock. (Also, in multistory communication buildings, an elevator should be located adjacent to the parts module for safe vertical movement of large communication equipment throughout the building.)

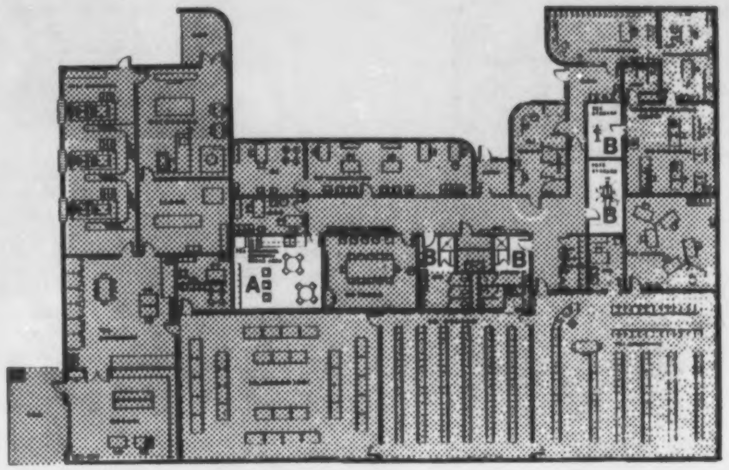
guidance 3. Efficiency and Accessibility of Admin. Spaces



A. Administration modules must be easily accessible to the public to minimize circulation and to prevent visitor interference with facility operations. The administration modules should provide a buffer and transition space between the exterior and interior secure spaces. Also, public corridors in the administration area should contain military unit logos and other display panels that relate to the "esprit de corps" and unit integrity of the communication station.

B. Administration spaces' integrated relationship will improve efficiency by minimizing public and administrative circulation and by producing a group adjacency to shared conference areas, secretaries, and waiting areas.

guidance 4. Personnel Support Spaces



A. The intense activities inside the DCS facility tend to generate mental fatigue among personnel. It is therefore necessary to create a change of environment for on-duty personnel to provide a break from the "hard surface" equipment room and work areas. The personnel support module should be directly adjacent to the operations room, but isolated acoustically and visually.

B. In addition, physical exercise equipment is recommended for DCS facilities located off military bases. The necessary showers and lockers should be similarly adjacent to the operations module for easy access and optimal use.

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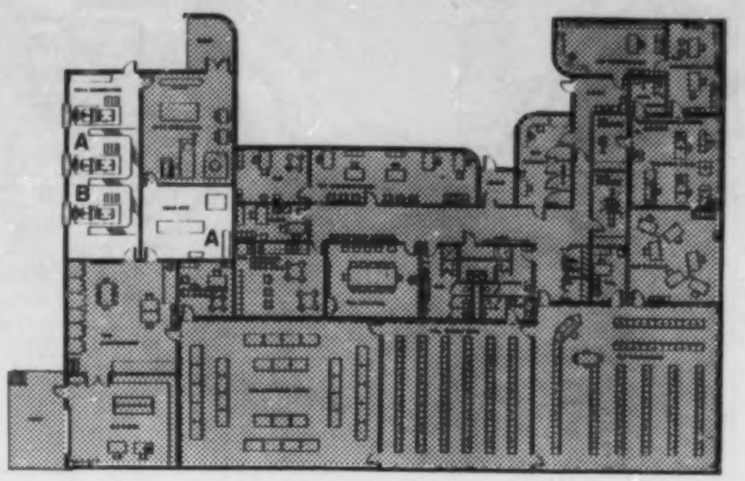
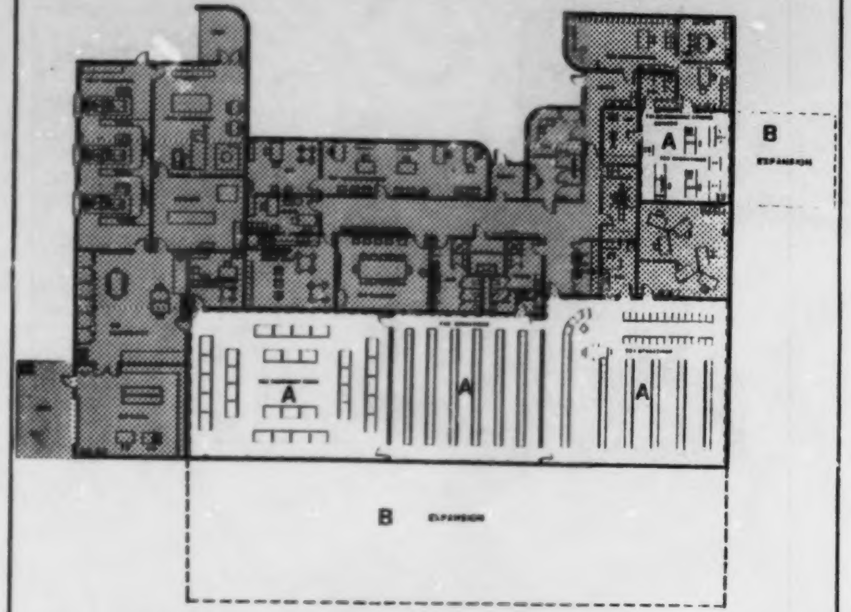
guidance 5. Integration of Power/UPS Modules



A. Modules that comprise the power and UPS gear should be contiguous and well integrated. Direct physical adjacencies provide economy by minimizing cable lengths and produce personnel efficiency through interaccess relationships.

B. Confining the power and UPS spaces to remote areas will minimize the impact of generator vibrations that could adversely affect the communications transmission.

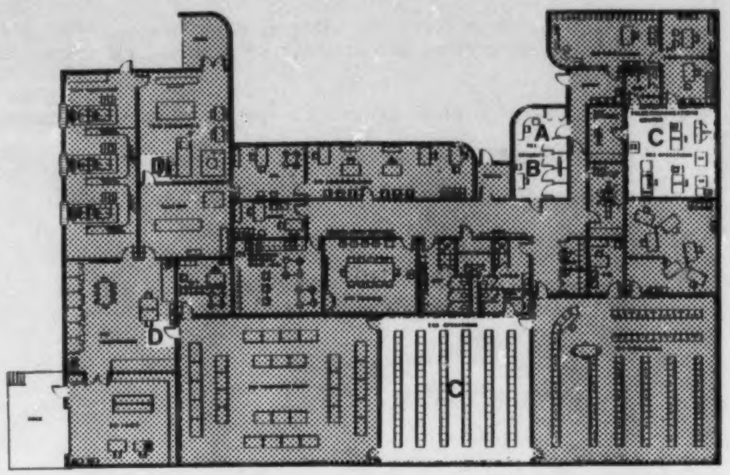
guidance 6. Facility Expansion



A. The equipment layout should be planned in a way that affords enough space for the installation of equipment capable of handling the maximum projected traffic load. The initial equipment layout should be such that the station facility's ultimate expansion can be done without extensive rearrangement of existing equipment.

B. Operations modules should be functionally isolated from support and power modules. Because of the increasingly rapid changes in communications technology, new demands on the spatial layout of operations modules can be expected in the future. Such spaces must be able to expand to accommodate new equipment and new functions. It is not anticipated that support and power spaces will need this same expansion capability and, therefore, may be located in their own areas; that is, facility design should allow operations modules to expand without greatly affecting the remaining functions.

guidance 7. Security Operation



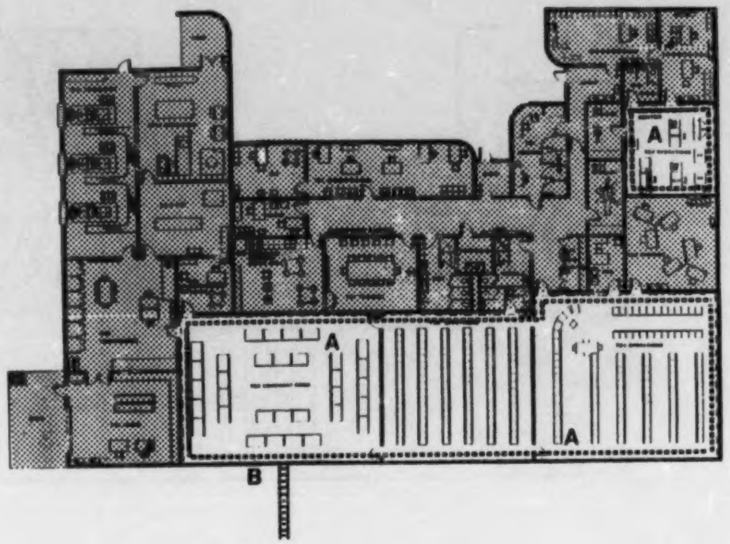
A. Security modules should be located to provide an overview for entry verification of visiting personnel. Additionally this module must be easily accessible to building occupants to facilitate efficient storage and distribution of weapons for personnel.

B. The security module will administer site security, monitor all intrusion detection systems, and initiate proper reactions to hostile threats. The security module should therefore be designed to provide overview and control over both site access and all exterior activities.

C. "Message" security is achieved by minimizing circulation between operations and cryptography modules, confining the modules to controlled areas, and providing disposal techniques to be performed or controlled by authorized personnel.

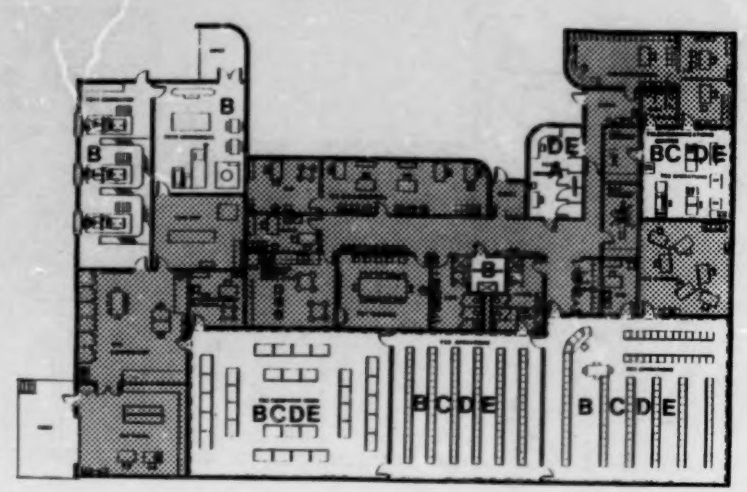
D. Required doors from other interior modules or from the outside that open into secure areas should have opening hardware only on the secure side.

guidance 8. Facility Security/Survivability



A. Conventional Class A vault construction is required for all spaces containing the communication system equipment--for example, operations, equipment, and tech control. Therefore, efficient construction methods and future building flexibility requirements can be met by locating these spaces in a contiguous relationship. These spaces usually require vault-type construction for a combination of four requirements: (1) HEMP protection, (2) TEMPEST shielding, (3) building intrusion resistance, and (4) fire protection. (See SB7, Security Systems--guidance for building security construction of Zone 4, Section 5b in Vol 2).

B. Communication facilities require waveguides in transporting the communications signal to and from the transmission/receiving equipment antennas. It is therefore necessary that the transmission/receiving module be located at a minimal distance from the antennas. In addition, waveguides must be physically protected to insure the facility's ability to perform its mission.



Occupancy classifications: Business (NFPA); B-2 (UBC)

Hazard of contents classification: Ordinary hazard

Sprinkler protection classification: Ordinary hazard--group 2.

Construction classifications/materials for fire protection (See Vol 2, the first figure in SB3, Fire Protection/Life Safety)

A. Type II--fire resistive (UBC) for security/armory spaces:

Construction Element	
Exterior walls	4-hour rated construction
Interior bearing walls	2-hour rated construction
Structural frame	2-hour rated construction
Permanent partitions	1-hour rated construction
Shaft enclosures	2-hour rated construction
Floors	2-hour rated construction
Roofs	2-hour rated construction

B. Type II--One-Hour (UBC) for battery, cryptography (RED/BLACK),* custodian, generator, operations,* mechanical, and transmission spaces:

All construction elements.......1-hour rated construction

Type II--N (UBC) for remainder of building spaces

All construction elements.......Noncombustible construction

Building Separation

Site-specific information is required. Comply with the second figure in Vol 2, SB3, Fire Protection/Life Safety.

.Interior finishes

See Guidance/Life Safety, Vol 2.

Fire protection systems

Automatic fire suppression

A water sprinkler system shall be provided throughout the entire facility.

C. A Halon 1301 or carbon dioxide system shall be provided under raised floor areas containing nonmetallic, sheathed, exposed cables when the space under the raised floor is used as an air plenum.

Automatic notification/alarm

A general alarm must be activated by the automatic sprinkler system.

D. Local alarms are required to sound only in the designated spaces; they are activated by smoke detectors.

Automatic fire detection

E. Smoke detectors are required to activate local alarms only in the designated spaces. In rooms containing raised floor areas, smoke detectors shall be located under the raised floor.

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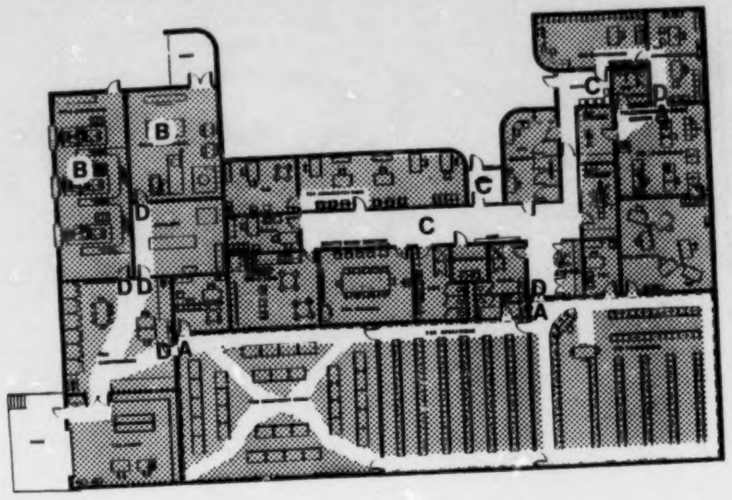
*See Vol 2, SB7, Security, for vault construction requirements that may be more stringent than those imposed by fire protection requirements.



OCCUPANT LOAD FOR DETERMINING EXIT REQUIREMENTS.

Occupant load factor: 100 square feet per person based on gross floor area (Business Occupancy-NFPA)

Occupant Load= (total facility) $\frac{17,555 \text{ sq ft}}{100}$ = 176 persons

Occupant Load= (vaulted area) $\frac{6,690 \text{ sq ft}}{100}$ = 67 persons

Occupant Load= (admin/support) $\frac{1,710 \text{ sq ft}}{100}$ = 18 persons

Exit capacities

Corridors--100 persons per unit of exit width for travel in either direction. The minimum width of any exit access corridor or passageway shall be 44 inches in the clear.

Doors--100 persons per unit of exit width (a 3-foot door provides 1.5 units of exit width, providing an exit capacity for 150 persons).

Number of exits

No less than two exits shall be accessible from every part of every floor. One exit is permitted when the room or area has: (1) a total occupant load of less than 100 persons, (2) direct exit to an open area outside the building at the ground level, and (3) a total travel distance on the same level of not over 100 feet. (If stairs are involved, they shall be no more than 15 feet in height and shall be provided with complete enclosures to separate the stairs from any other part of the building.)

Exit travel distances

Required exits shall be located to allow access without passage through areas that may be locked. No dead end corridor shall exceed 50 feet. Travel distance to exits shall be no more than 300 feet when the building is protected throughout by an approved automatic sprinkler system.

Arrangement of means of egress

Exit access and travel routes to exits are shown in the plan.

A. Exit doors in vaulted areas that contain communications equipment are secured and permit egress out only. Exit access routes through vaulted areas from spaces outside the vaulted area are not permitted for security reasons.

B. Two means of egress shall be provided from higher hazard areas, including mechanical and generator spaces. Exit access from any other space may not pass through the mechanical or generator spaces (see exit marking). For security, when mechanical or generator spaces have exit access routes through interior spaces, exit access doors from these spaces, when opened, shall sound an alarm and transmit a signal to the annunciator panel in the security space. Access for normal maintenance in mechanical and generator spaces shall be through the exterior doors.

guidance

Interior finishes

C. Interior finish in exit access corridors shall be Class A only.

Interior finish in the remainder of the building shall be Class A or B only.

Means of egress lighting

Exits and exit access, including stairs, aisles, corridors, and passageways leading to an exit, shall be lighted continuously during times when the conditions of occupancy require means of egress to be available. Lighting should be no less than 1 footcandle measured at the floor.

Emergency lighting

Emergency lighting shall be provided in windowless buildings for designated aisles, corridors, and passageways leading to an exit. Emergency lighting shall stay at least 1 footcandle throughout the means of egress for 1.5 hours in the event of normal lighting failure.

Marking the means of egress

Exits shall be marked by an approved sign readily visible from any direction of exit access. Signs shall be placed such that no point in the exit access is more than 100 feet from the nearest visible sign.

D. Doors located or arranged so that they are likely to be mistaken for exits shall be identified by a sign reading "NOT AN EXIT."

guidance

High-Frequency Radio [HF]

HF1 Security HF-2
HF2 Operations Administration HF-8
HF3 Personnel Support/Training HF-14
HF4 Transmission HF-18
HF5 Receiving HF-26
HF6 Parts/Maintenance HF-32
HF7 Screen Room HF-38
HF8 Control Monitoring HF-42
HF9 Generator/UPS HF-48
HF10 Mechanical HF-58
HF11 Dummy Load Area HF-62
HF12 Storage HF-66
HF13 Antenna Fields HF-70
HF14 Standardized Modules-Transmission HF-124
HF14 Standardized Modules-Receiving HF-134

Communication satellites now carry modern, long-haul telecommunications circuits, relegating the more expensive (per circuit mile) and less reliable high-frequency (HF) modes to a backup role. However, space technology and electronic warfare have advanced, making satellite communications, and thus, military long-haul communications, highly vulnerable in the event of an international conflict involving the United States. In that case, HF modes may be the only alternative backup to military strategic communications. For this reason, HF radio communications have received renewed interest by military telecommunications planners. (87) Vol 1, 10

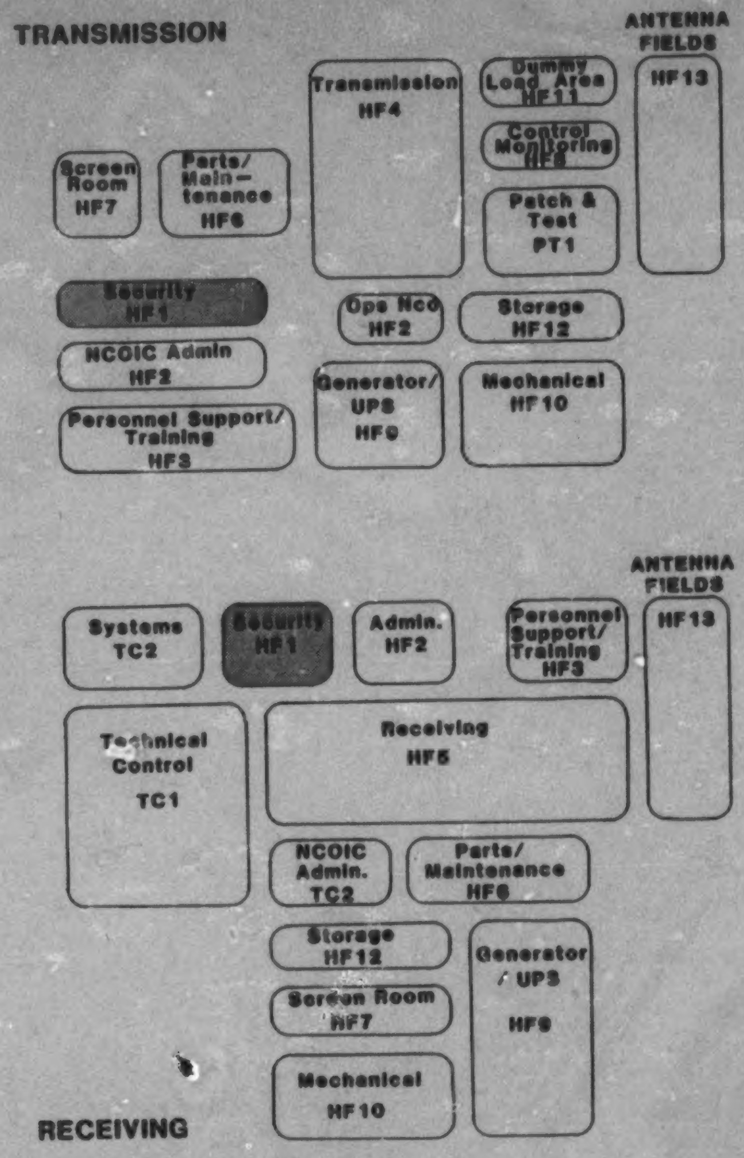
HF communications facilities occupy huge physical spaces. .Antenna fields that use large rhombic or log-periodic antennas may require hundreds of acres of land for antenna systems alone. Transmitter buildings must also be large because of high-powered HF transmitters' physical size. The size and layout of any HF facility will be dictated by the number of circuits and radio systems required, which in turn, dictates the number and size of antennas and other hardware required. (87) Vol 1, 17

Receiver sites should be located no closer than 10 miles to transmitter sites. It is worth consideration to have the receiver site to one side or to the rear of the transmitter site (assuming the transmitter site has a definite arc of interest). In addition, transmitter sites should not be located near other facilities that use radios, such as airports, highways, cities, or industrial areas. High-gain HF antennas require area ranging from 1 acre for a rotatable log-periodic antenna to 15 acres for a large rhombic antenna. (87) Vol 1, 18

The large facility's complexity grows with the antenna field's ability to support additional antennas. For a receiving facility, the antenna field does not play such a limiting factor, since multicouplers can be used to supply five to ten receivers with the same directional antenna (87) Vol 1, 19

The physical size of a transmitting or receiving facility also is dictated by the traffic it is expected to handle now and in the future. Simultaneous transmission to different points will require seperate transmitters and antennas. (87) Vol 1, 19

SECURITY HF1


TRANSMISSION
ANTENNA FIELDS
HF13
Transmission HF4
Dummy Load Area HF11
Control Monitoring HF8
Screen Room HF7
Parts/ Main-tenance HF6
Patch & Test PT1
Security HF1
Ops Nco HF2
Storage HF12
NCOIC Admin HF2
Generator/ UPS HF9
Mechanical HF10
Personnel Support/ Training HF3
ANTENNA FIELDS
HF13
Systems TC2
Security HF1
Admin. HF2
Personnel Support/ Training HF3
Technical Control TC1
Receiving HF5
NCOIC Admin. TC2
Parts/ Maintenance HF6
Storage HF12
Screen Room HF7
Generator / UPS HF9
Mechanical HF10
RECEIVING

function

This component provides overview for verifying visitors before they enter the facility. The Intrusion Detection System and fire alarm equipment are monitored in this area. Also, when required, facility personnel weapons are stored and distributed here.

policy/sop

1. The building site must withstand intrusion by individuals or groups intending to compromise the security of the information transmitted and received at DCS facilities.

2. The overall approach to providing security at DCS sites consists of five elements: (1) intrusion deterrence, (2) intrusion detection, (3) alarm assessment, (4) component and physical plant hardening, and (5) security or response force personnel. Intrusion deterrence is intended to produce a psychological state of mind in a potential intruder that intrusion will result in unacceptable counteraction. Intrusion detection is intended to provide an alarm to the operating activity or security personnel that an unauthorized intrusion has occurred at a DCS site. Alarm assessment is intended to verify that an intrusion alarm was activated by a threat against the DCS site. Component hardening of the physical security system is intended to delay the damages or to limit the amount of damage that can be inflicted on a site. Security force is intended to delay, stop, or mitigate the actions of an intruder. Every DCS site security program shall be prepared to include these five elements. (9) 4.3.3.1

3. The security alarm system should also be wired into either Tech control or the operation area spaces. These spaces will be staffed 24 hours per day, and the same personnel could monitor the security system. The receiving/administrative spaces usually are staffed only 8 hours per day during the week.

4. Most OCONUS sites have local national (LN) guards that maintain security at the perimeter fence during daytime hours. At night this function reverts to site shift communication personnel. All entry alarms should be "remoted" to locations within the operations building similar to that of closed-circuit television (CCTV) monitors. This will preclude assigning critical personnel to security duties. All alarm systems should be "remotable" to the operations console.

issues and assumptions

1. Full-time lighting versus "on-demand" lighting

Continuous lighting (stationary luminaires) is the most common security lighting system. It consists of a series of fixed luminaires arranged to flood a given area continuously with overlapping light cones during the hours of darkness. Standby lighting differs from continuous lighting in that standby lighting is intended to create an impression of activity. The luminaires are not lighted continuously, but are either automatically or manually turned on at random or when suspicious activity is detected or suspected by the security force or the intrusion detection system (IDS). This technique may offer great deterrent value as well as economy in power consumption. (37) 13.1-120

2. Automatic actuation of security lighting versus manual lighting

A deterrent lighting system can be developed to turn lights on at random or, rather than randomly activating the luminaires, an IDS sensor can be used to turn on the lights when an intruder is detected. This type of active lighting system provides maximum deterrent value at a low duty cycle. (37) 13.1-124 Automatic actuation of lights for normal operations seems most advantageous; however, manual override should be provided for control.

activities

1. Viewing personnel entering the complex.
2. Monitoring IDS equipment.
3. Operating facility physical security program.
4. Distributing and storing personnel weapons.

personnel

1. One.

equipment*

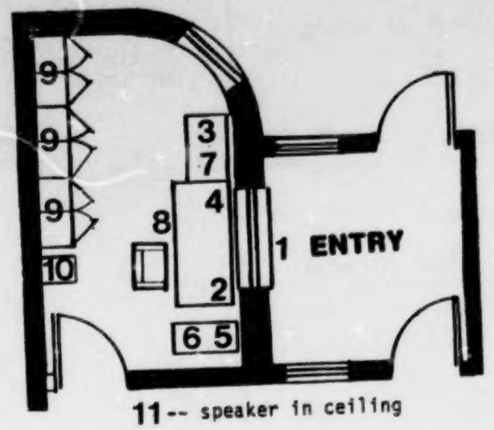
1. Pass window for identification.
2. Annunciator panel (sensor information).
3. Closed-circuit TV.
4. Gate control for perimeter security fencing.
5. Exterior lighting control.
6. Communication link to host agency.
7. Alarm for intrusion detection to host agency security office.
8. Desk (or counter unit) with chair.
9. Racks for personnel weapons. Weapon distribution is through a door with a daygate for passing through.
10. Humidifier.
11. Intercom speaker.

* see "guidance" box for example layout of all equipment listed.

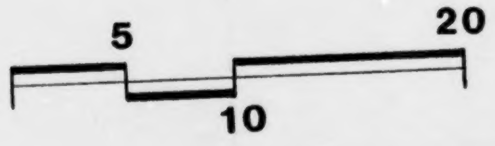
requirements	criteria	commentary
1. Enough space to accommodate IDS equipment and personnel associated with security component.	**1.** Provide space for one person who verifies and monitors the facility's security. This area varies with size of facility, but typically is 400 to 500 square feet.	
2. Visual verification of entering personnel.	**2.** Provide a pass window.	
3. Communication and electronic monitoring lines.	**3.** Coordinate IDS components into a centralized module. Provide an annunciator panel with telephone and intercom link-ups. The operation room console should have remote alarms along with a CCTV monitor.	
4. Resistance against penetration from the outside and for the armory.	**4.** Windows should be glazed and hardened to prevent penetration (bullet-proof glass). Windows also should be designed for full visibility over approaches to the point of entry.	**4.** See Vol 2, SB7, Security (Zone 3), for more information.
5. Interior finishes suitable for durability, maintenance, and room function.	**5.** Floor--Vinyl asbestos tile. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	**5.** See also Vol 2, SB2, Interior Construction and Finishes.
6. Acoustical isolation and attenuation for a nondisruptive environment.	**6.** The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum), floor surface at NRC .25 (minimum), and divider partitions (if used) at .85.	
7. Adequate lighting to review entering personnel and to monitor equipment.	**7.** Lighting shall be specially engineered. Low levels of lighting may be required to permit observation of luminous panels without reflected glare or undesirable contrasts in brightness. Separately controlled luminaires shall be provided for normally lighted operations and clean-up; this lighting should have an ambient level of 70 footcandles using fluorescent fixtures.	**7.** For further information on quality of lighting design using the ESI concept, see Vol 2, SB2, Electrical Lighting.
8. Thermal regulation and other comfort features for the occupant.	**8.** Maintain temperature at 68°F (heating) or 78°F (cooling) with a 5 cubic feet per minute per person outside air ventilation rate. A dehumidifier may be required in the armory. Provide a chair with seat height adjustment, casters, swivel, and independent back rest adjustment.	**8.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
9. Electrical power.	**9.** Provide 120/208 electrical service. 120-volt receptacles should be located for convenience at all workstations and workbenches at the appropriate height and for every 10 linear feet of wall. Frequency levels should be 50 to 60 hertz ± 5 percent.	**9.** See also Vol 2, SB2, Communication Station Buildings--Electrical.

requirements	criteria	commentary
10. Fire protection/life safety criteria are based on the assumption that this facility houses critical equipment and data that has a severe strategic fire loss potential.	**10.** Interior enclosure walls--2-hour fire-rated construction in armory, security, and entry. Interior doors--1.5-hour fire-rated doors in armory, security, and entry. Interior finish- Class A or B only. Corridor and entry finish--Class A only. Automatic fire detection--Local alarm. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**10.** See Standardized Modules-Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety for more information.

guidance



11-- speaker in ceiling



guidance

1. Location

The minimum area is determined from IDS monitoring equipment physical dimensions.

Direct access to facility entrance is required.

This area must have no direct access to C-E equipment.

This component can be combined with the administration function in the small module package.

2. Verification

Orient windows to allow visual security of arriving personnel. In some circumstances, it works well to use mirrors to show the total front face of the building before the door is opened. This also prevents the security officer from confronting unexpected hostile action when leaving.

3. Monitoring

Three shifts in a 24-hour period are assigned for these activities if the personnel are available. At some smaller facilities, the security alarm and detection devices should also be wired into the operations, operations administration, or control monitoring space so that operation shift personnel can monitor the security system when the security space is not staffed.

Alarm system--Provide a wall-mounted alarm terminal panel in the security room. The following alarms will terminate there:

- Smoke/fire detection
- Intrusion detection of all doors and barred openings.

The termination board or its associated housing should have all alarm terminations identified clearly with permanent marking or labels. This allows future extensions of these connections to a control and fault alarm system. The alarm sensors should incorporate only dry contacts (no voltages) and should use two conductor shielded cables in the circuit runs (or in conduit) to the consolidated terminal panel noted above.

Intrusion detection system--The IDS should conform to Corps of Engineers Guide Specification CE 304.01. Provide magnetic intrusion alarm switches on all exterior doors and openings greater than 7.6 feet at the perimeter into the building. Terminate all circuits in the wall-mounted alarm panel. The door alarm is to sound then the door moves 1/2 inch toward an open direction.

guidance

The various approaches to an alarm display problem offer a wide range of capabilities, but also present several distinct disadvantages. In selecting an alarm display system for a specific installation, it is essential that the features and capabilities required for the intended application be well understood. In particular, there is no one "best" system for transmission and display of security information. Rather, a system should be selected to meet the needs of the specific installation. It should also be noted that many systems may provide more capability than is needed or desired and that paying for unused features would tend to increase the system's cost. See Vol 2, SB7, Security Systems, for more information.

4. Primary entrance door

The primary personnel entrance door should be secured with a jimmy-proof, deadbolt extension operated by a combination lock in conformance with UL Standard 768 and Military Specification MIL-L-15596. The primary entrance door should also be equipped with panic bolts and a rim with a box mullion in conformance with Federal Specification FF-H-106. The panic bolts should be UL-approved. If required for routine access control, an electrically controlled latch mechanism is authorized for installation. RF emissions should meet the requirements of MIL-STD-461 of Class II-A equipment when applicable. (5) 3-5-9

The personnel entry doors should be the steel, single-swing type with a steel frame. Another option is a door constructed of hollow metal with a 1/8-inch steel plate face.

Personnel entry doors should also be equipped with a "peephole" wide angle lens. Doors should have an inside plate to cover the peephole when it is not in use.

Hinges on both the exterior personnel and equipment doors must be welded to prevent removal of hinge pins if pivots and pins are on the outside.

7. Lighting design

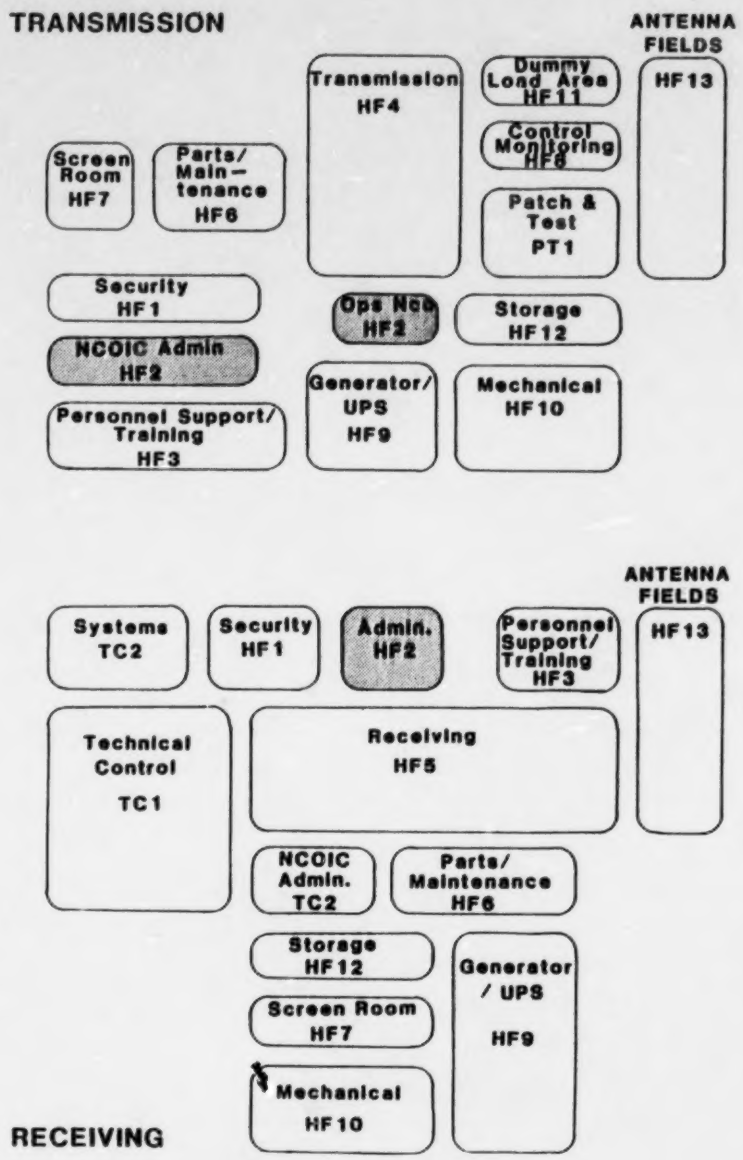
To reduce glare at video digital terminals (VDTs), use fluorescent light fixtures with specular parabolic louvers. A louver with cell dimensions of 1.5 by 1.5 inches or smaller will give a high visual comfort probability (VCP) value. A diffuser along with a parabolic louver may also be helpful. Some pigmented acrylic lenses and nonparabolic metal louver panels can also have high VCP values.

The suggested cell size for a parabolic louver is 1 by 1 inch down to .5 by .5 inch. On tall ceilings, the cell depth must be greater; this may dictate a larger cell size.

Glare from windows and reflections from walls and other surfaces must be controlled, especially on the surface immediately behind the VDT. Walls and work surfaces with a matte finish are best. Wall carpeting is also recommended for its noise control and virtual elimination of reflections.

guidance

OPERATIONS ADMINISTRATION HF2


TRANSMISSION
ANTENNA FIELDS
HF13
Transmission HF4
Dummy Load Area HF11
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Generator / UPS HF9
Mechanical HF10
RECEIVING

function

The purposes of this element are to: (1) provide administration space that specifically supports the operations activity, (2) establish and maintain the station administrative processing of personnel records, and (3) implement written and verbal SOP directives from Chain of Command orders, host agency regulations, and DCA policy for DCS. The administration area also provides a buffer and transition space between exterior and secure interior spaces.

policy/sop

issues and assumptions

1. Enclosed office versus open area workstation

The NCOIC and an assistant usually occupy an office workstation in the operations room itself. This makes their work more difficult because of high noise and activity levels. If an enclosed office is provided, a view window to the console area must be installed.

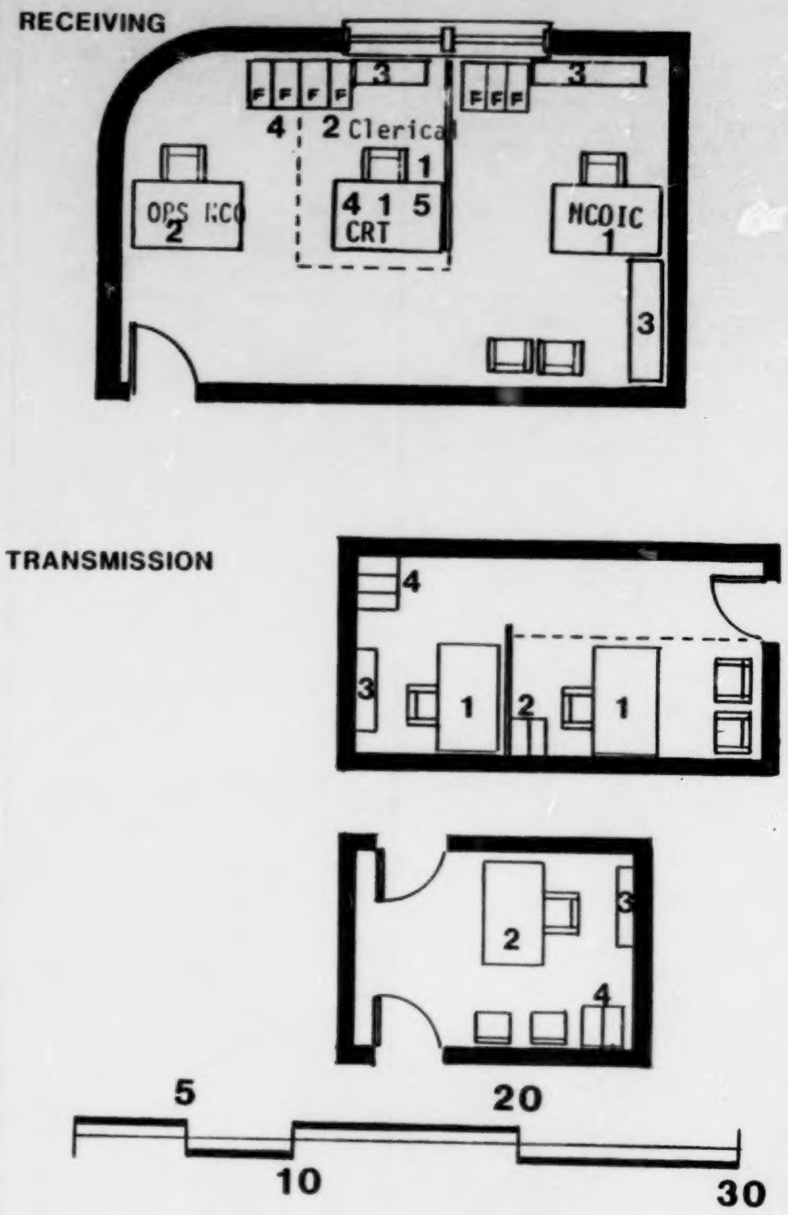
activities	personnel	equipment
Officer-in-charge (OIC) 1. Distributing directives, orders, and policy statements, both written and verbal, to shift supervisors. 2. Initiating evaluation of equipment capabilities. 3. Developing personnel training plans and equipment evaluations. 4. Conferring with personnel one-on-one. 5. Writing and typing reports. 6. Communicating operations and service functions. 7. Managing operations function.	1. NCOIC. 2. Operations NCOIC.	1. One NCOIC workstations: desks with chairs in open area or with dividers. 2. OPS NCOIC workstation: desk with chair in open area or with dividers. 3. Bookshelves--20 linear feet. 4. Five files, five drawers each.
Clerical 1. Typing, reception, and coordination of command/control process for the noncommissioned officer in charge (NCOIC). 2. Filing/posting of operations and personnel documents. 3. Providing courier service for paperwork.	1. E-2 clerk.	1. Clerk workstation: desk with chair in open area. 2. Two files, five drawers each. 3. Bookshelves--45 linear feet. 4. Typewriter/word processor. 5. Operational voice intercom control.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate equipment and furniture associated with the administration function.	1. Provide administrative space for two supervisory personnel with the required desks and chairs, bookcases, and file cabinets. Approximately 200 square feet are needed for two persons.	
2. Visual contact from offices to the operations floor to provide management with better opportunities to optimize personnel effectiveness.	2. Locate the administrative office space adjacent to the operations center console.	
3. Communication lines (outside and inside) for emergency operations and internal interaction between offices and operations floor.	3. Coordinate telephone and intercom needs with the installation.	
4. Interior finishes suitable for durability, maintenance, and room function.	4. Floor--Vinyl asbestos tile. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	4. See also Vol 2, "Site and Building Information," SB2, Interior Construction and Finishes.
5. Acoustical isolation and attenuation for a nondisruptive environment.	5. The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .90, floor surface at NRC .50, and divider partitions (if used) at .85.	5. See reference 201, page 3-4, Table 3-2.
6. Adequate lighting.	6. Use artificial lighting or natural if present. By quantitative and qualitative evaluation, provide: 20 to 30 footcandles general lighting. 60 to 80 footcandles task lighting. Surface reflectances: Ceiling--80 to 90 percent. Walls--40 to 60 percent. Floors--20 to 40 percent.	6. For further information on quality of lighting design using the ESI concept, see Vol 2, SB2, Electrical Lighting.
7. Thermal comfort.	7. Regulate temperature at 68°F (heating), 78°F (cooling), with a 5-cubic feet per minute per person outside air ventilation rate.	7. See also Vol 2, SB2, Communication Station Buildings--Mechanical.

requirements	criteria	commentary
8. Electrical power.	**8.** Install 120/208 electrical service. Receptacles (120-volt) should be located for convenience at each workstation and workbench at a suitable height for every 10 linear feet of wall. Electrical power must fall within the 10,000- to 500,000-watt range. Frequency levels should be at 50 to 60 hertz ± 5 percent.	**8.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
9. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**9.** Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**9.** See Vol 2, Standardized Modules--Building Design Principles, and SB3, Fire Protection/Life Safety, for more information.

guidance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guidance

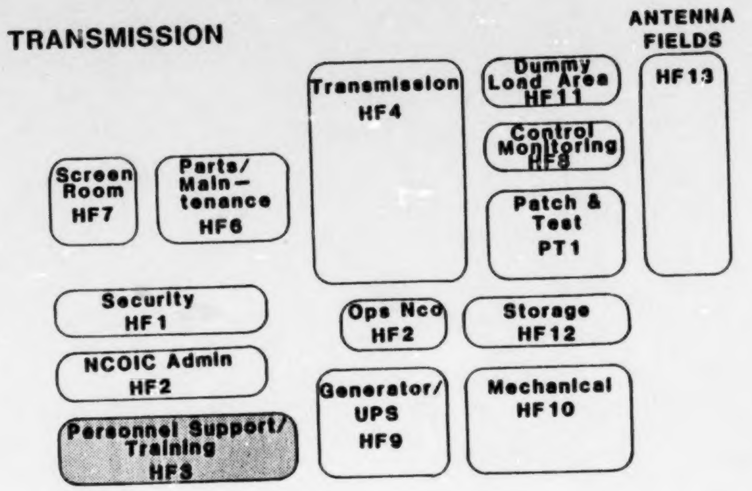
6. Work area

Light fixtures that provide uniform intensity should be equipped with light control lenses or specular parabolic louvers to minimize glare on working surfaces. The work area should also be provided with adjustable task lighting.

guidance

guidance

PERSONNEL SUPPORT/TRAINING HF3


TRANSMISSION
ANTENNA FIELDS
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Control Monitoring HF8
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Parts/ Main-tenance HF6
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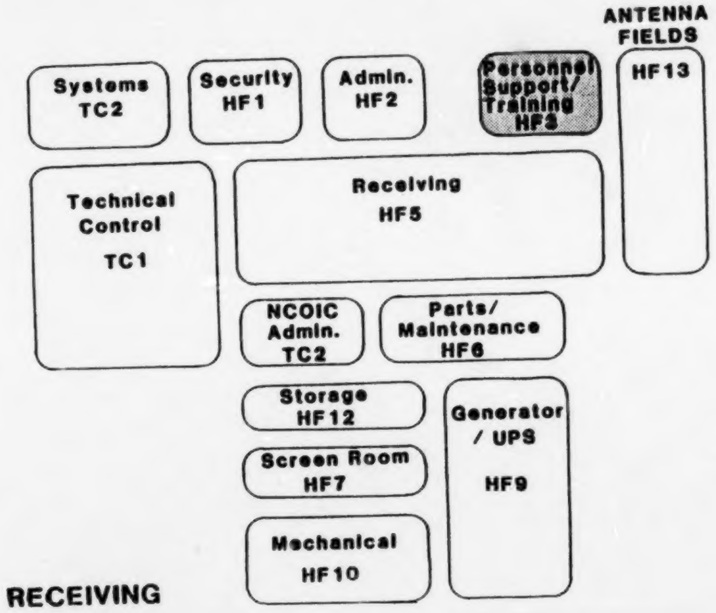
Ops Nco HF2
Storage HF12
Generator/ UPS HF9
Mechanical HF10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Parts/ Maintenance HF6
Storage HF12
Screen Room HF7
Mechanical HF10
Generator / UPS HF9
RECEIVING

function

This component creates a change of environment for on-duty personnel to provide a break from the hard-surface equipment room and work areas.

It also functions to enhance personnel abilities and effectiveness, both technically and personally. Development and implementation of the station master training program is done here.

policy/sop

Training

1. The intense activities in the DCS facility generate personnel fatigue, making it necessary to separate personnel from the communication function.

2. Current policy requires personnel to have a 15-minute break every 3 to 4 hours. Typical schedules also allow 30-minute meal breaks.

3. Most communication personnel "brown bag" their meals since they cannot leave the facility during a shift. Therefore, basic food preparation capability is required: sink, hot plate, refrigerator, cabinets, and range.

Personnel support

1. Technical training occurs at two levels: (1) hands-on training, i.e., working directly with the communications equipment, and (2) learning from manuals, publications, and audiovisual equipment. The physical training also occurs at two levels: (1) interior individual exercise and (2) exterior small-group recreational activities, especially at remote DCS facilities that are not on a military installation.

2. Current policy requires personnel to be allowed time to train technically while on-duty at the facility.

3. Training usually is done during the times that the communication activity is at its lowest level.

4. Some communications personnel are engaged in a Career Development Course (CDC); thus, a training area is required. The Air Force counterpart is the Quick Training Package (QTP).

5. Training usually is conducted by the shift supervisor or a lead NCO/CO who is also on-duty.

6. In fire/life/safety training, safety implies the absence and/or control of conditions that can cause personal injury, death, damage to, or loss of equipment or property. Within the system, safety is concerned with the elimination or control of factors affecting the safe and efficient operation of personnel, equipment, and facilities organized to attain a common goal. The objective of safety training therefore is to insure maximum freedom from inadvertent and possibly destructive mishaps resulting from facility equipment, procedural, or personnel deficiencies during all phases of system operation. (70) 15-30

issues and assumptions

1. Three-shift versus four-shift impact on training time available

Most facilities operate on a three-shift basis:

- Day shift 8 a.m. to 4 p.m.
- Swing shift 4 p.m. to 12 a.m.
- Midshift 12 a.m. to 8 a.m.

By having personnel assigned to four shifts instead of three, one group could be a "training shift" that would be on duty during the day shift; thus, the peak activity period would have double the personnel available if required, plus give trainees the best opportunity to interact with facility functions.

The four-shift concept, however, assumes one or both of the following:

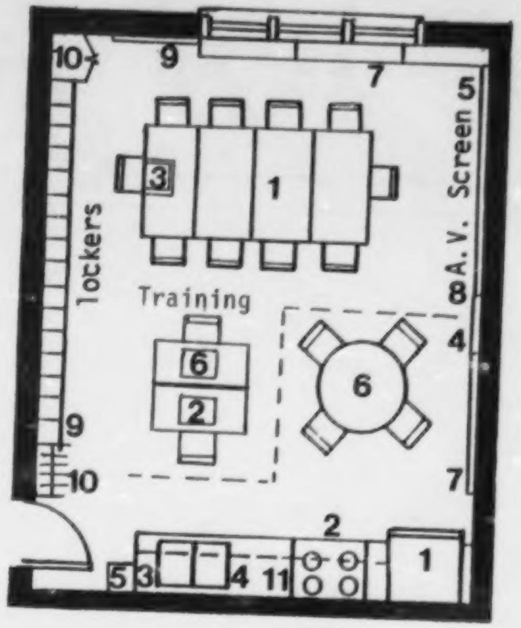
- More persons will be assigned to the site
- Staffing for the three operating shifts can be reduced.

activities	personnel	equipment*
1. Relaxing. 2. Reading. 3. Eating. 4. Storing food. 5. Preparing food. 6. Storing personal items such as coats and books.	1. Two to eight * see "guidance" box for example layout of all equipment listed.	1. Refrigerator. 2. Range and range hood. 3. 20 x 30 inch sink in countertop which is a 6-foot minimum with cabinets above. 4. Coffee machine. 5. Trash receptacles. 6. Table with chairs for four. 7. Bulletin boards. 8. Intercom speaker. 9. Storage lockers for each person. (Not required for personnel who have private offices.) 10. Coat rack. 11. Microwave oven (if communication equipment is not affected).

activities	personnel	equipment *
Technical training 1. Observing and evaluating personnel records; conducting personnel interviews to determine training requirements. 2. Developing overall master training plan and presenting special MOS training module program for a specific focus. 3. Studying manuals and other publications. 4. Watching video cassettes, 16-millimeter movies, and slides. 5. Instructing in fire/life/mission safety.	Instructors 1. Commander. 2. NCOIC. 3. Civilian technicians (not an office area for personnel). * see "guidance" box for example layout of all equipment listed.	Classroom/conference room 1. Table and seating for 10. 2. TV monitor/CRT terminal. 3. Viewgraph projection. 4. Charts and display panels. 5. Audiovisual projection and screens. 6. TEC library monitors. 7. Library of written instructional materials--20 linear feet. 8. Chalkboard. 9. Tackboard for training and information bulletins. 10. Audiovisual equipment storage cabinet.
Physical training Involves mandatory military training requirements for physical fitness, weapons qualifications, and CBR training.		Fitness area 1. Exercise equipment: 8 by 4 foot mat, weight set, and exercycle. 2. Exterior area for volleyball and half-court basketball. 3. Athletic and recreational items; balls, bats, horseshoes, etc.

requirements	criteria	commentary
1. Enough space to accommodate equipment and furniture associated with the personnel support/break area.	1. Provide approximately 500 square feet of space for equipment and furniture to accommodate up to 15 personnel.	
2. Visual separation from the communications equipment.	2. Provide visual separation that also allows viewing of the operations area when desired. Supply comfortable furniture and carpeting (earth tones are recommended).	
3. Interior finishes suitable for durability, maintenance, and room function.	3. Floor--Vinyl asbestos tile and area carpeting. Base--Glazed structural units, rubber, vinyl or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	3. See also Vol 2, SB2, Interior Construction and Finishes.
4. Acoustical isolation and attenuation for a nondisruptive environment.	4. The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum), floor surface at NRC .25 (minimum), and divider partitions (if used) at .85.	4. See reference 201, page 3-4, Table 3-2.
5. Lighting suitable for reading (task and ambient).	5. Use 20 to 30 footcandles for ambient lighting and 100 footcandles for task lighting.	
6. Thermal comfort.	6. Control temperature for 68°F (heating) and 78°F (cooling) with a 5-cubic feet per minute per person outside air ventilation rate.	6. See also Vol 2, SB2, Communication Station Buildings--Mechanical.
7. Electrical power.	7. Provide 120/208 electrical service. 120-volt outlets should be installed for every 10 linear feet of wall. Counter height outlets are required for a coffee maker, mixer, microwave oven (when permitted), and other appliances.	7. See also Vol 2, SB2, Communication Station Buildings--Electrical.
8. Fire protection/life safety criteria are based on the assumption that this facility is windowless and, in addition, houses critical equipment and data that have a severe strategic fire loss potential.	8. Interior finish--Class A or B only. Corridor finish--Class A only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	8. See Standardized Modules--Building Design Principles and Vol 2, SB3, Fire Protection/Life Safety for more information.

guidance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lockers
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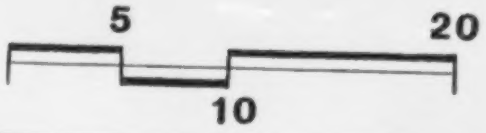
8 -- speaker in ceiling



guidance

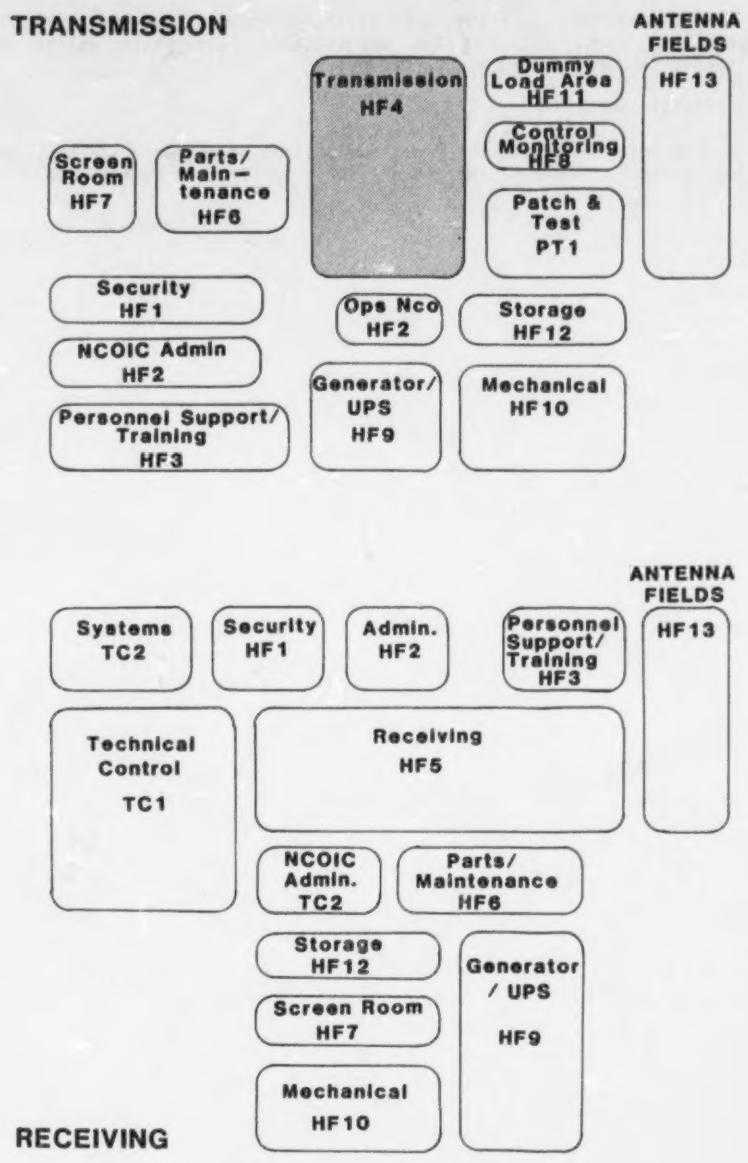
1. Location

The personnel space should be directly adjacent to the operations room, but isolated acoustically (absorptive walls) and visually (a curtain hung at the window).

3. Visual comfort

The color contrast, textures, and designs of the wall, ceiling, and floor surfaces should minimize glare for a comfortable environment.

TRANSMISSION HF4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Mechanical HF10
Generator / UPS HF9
RECEIVING

function

This area contains the equipment that transmits DCS communications and other information.

policy/sop

issues and assumptions

1. Electromagnetic compatibility (2) 5-43

Electromagentic compatibility (EMC) is a complex subject, so that specialists often must perform the type of EMC study needed to insure the equipment or equipment layout produces no interferences or radiation hazard.

DOD is working on new regulations to control permissible levels of EM pollution of the frequency spectrum. This work reflects the concern for environmental protection. Radiation hazards also are being regulated through concern for occupational safety. Engineering agencies working for the Government must therefore know the legal and regulatory aspects of EMC and radiation hazards to meet these requirements.

Military specifications on EMC such as MIL-STD-461, -462, and -463 are intended to control and achieve an acceptable figure of merit or quality in the development of new communications equipment. They do not eliminate the need for EMC engineering in facility design. In addition to equipment quality, the frequency selection, nearness to other facilities and, to some extent, the facility design itself are variables in the interference generation problem. (2) 5-43

2. Determining the correct shielding procedure

A comprehensive approach to the shielding of equipment from radio-frequency interference (RFI) or TEMPEST involves (a) a building layout to optimize inherent facility shielding conditions, (b) suitable location of all electronic equipment and signal cables, and (c) selection of effective shielding materials and construction components.

See Vol 2, SB4, for additional guidance information.

3. Determining the occupancy of this room

Noise levels may prohibit staffing these spaces for anything other than necessary activities. In addition, temperature control may contribute to making these spaces uncomfortable for occupancy.

activities

1. Testing and maintaining transmission equipment.

personnel

equipment *

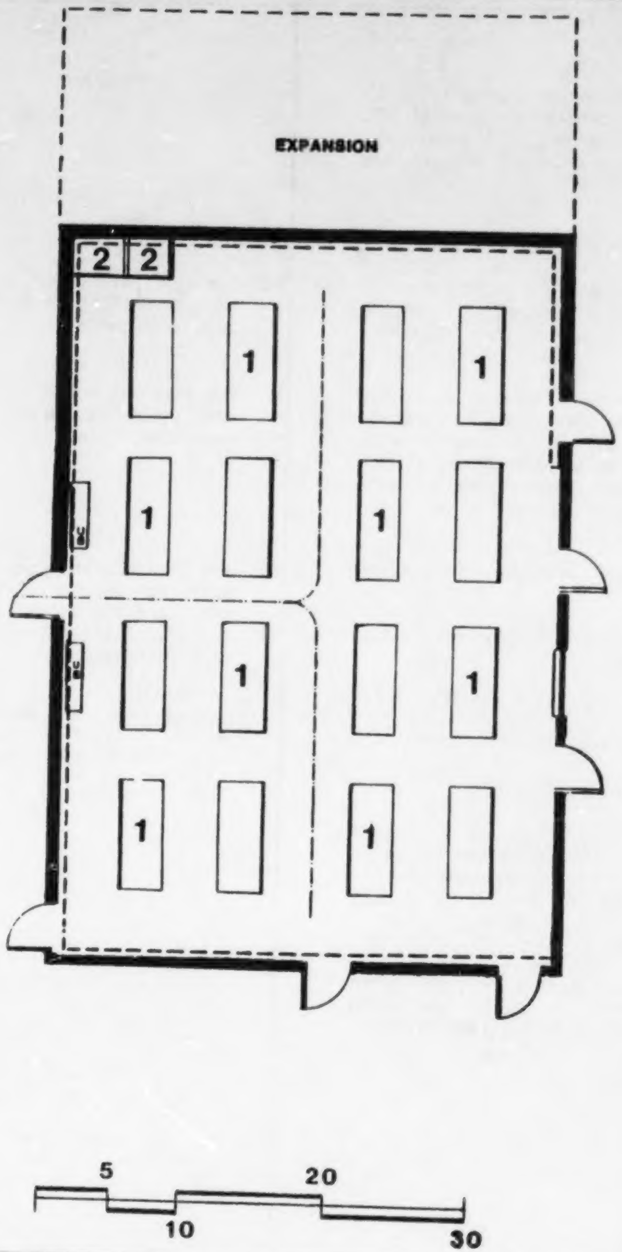
1. Transmission system.
2. Carts for storage.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for laying out transmission equipment for storing instruments, and for inspecting and testing the equipment. Space also must accommodate the administrative needs associated with electronic maintenance.	**1.** The area required varies according to the type and number of transmitters. (See Guidance example.) A 48- or 72-inch workspace behind all radio equipment is required for inspection, testing, and repair. (See Guidance example.)	
2. Utility system controls.	**2.** Provide remote monitors for both general and communication power supplies and for the environmental HVAC control systems.	
3. Monorail hoist.	**3.** Provide a 1-ton monorail hoist for easy transport of communication equipment.	
4. EMP/HEMP shielding.	**4.** Shielding is necessary for survival and uninterrupted functioning when the facility is subjected to electromagnetic pulse (EMP) and high-altitude electromagnetic pulse (HEMP). Protective measures are based on intercepting the incident energy and dissipating it or reflecting it away from the threatened device, equipment, or facility.	**4.** See Vol 2, SB5, EMP/HEMP Protection for more information.
5. RFI shielding.	**5.** Shielding is required in electrical and electronic equipment to prevent the equipment from propagating interference and to protect it from the effects of interference propagated by other electronic devices. (15a)7	**5.** See, Vol 2, SB4, Grounding, Bonding, and Shielding.
6. Special floor system.	**6.** Raised or false floors may be necessary for proper cooling, depending on the type of equipment installed. Some of the heavier equipment will require cable trenches rather than a raised floor.	**6.** See also Vol 2, SB2, Communication Station Buildings--Architectural.
7. Interior finishes suitable for durability, maintenance, and room function.	**7.** Floor--Vinyl asbestos tile panels. A raised floor system shall be used over a concrete floor that has a dusted-on finish containing a hardener. See Vol 2, SB2, Interior Construction. Base--Glazed structural units, rubber, vinyl or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster and acoustic tiles to within 4 feet of the floor. Ceiling--Acoustic tile.	**7.** See also Vol 2, SB2, Interior Construction and Finishes.

requirements	criteria	commentary
8. Acoustical isolation/attenuation for variable noise levels produced by electrical equipment.	**8.** Adjacent room walls should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum) and floor surface at NRC .25 (minimum). Acoustic tile is also required to within 4 feet of the floor.	
9. Adequate lighting.	**9.** Ambient: 20 footcandles. Task (testing and inspection): 70 to 100 footcandles.	
10. Proper environmental control for electronic equipment.	**10.** Temperature must be maintainable at 73°F (±2°), with 50 percent relative humidity (±5 percent). Provide filtered air in the transmission area. (See MIL-HDBK-411A.)	**10.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
11. Electrical power.	**11.** Install 120/208 electrical service. Electric power may fall within the 10,000- to 500,000-watt range. Frequency levels should be 50 to 60 hertz ± 5 percent. Provide utility 120-volt receptacles at the sides of each transmitter for test/cleaning/maintenance equipment. Supply main power breakers at each transmitter for safety.	**11.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
12. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**12.** Vaulted enclosure walls--2-hour (minimum) fire-rated shielded construction. Interior doors in vaulted walls: 1.5-hour fire-rated doors; shielded doors and frames. Interior finish--Class A or B only. Automatic fire detection--Local alarm. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility. Manual emergency equipment power shut-off at exits. Under raised floor area--Automatic fire detection: local alarm. Automatic Halon 1301 suppression system if cross-zoned or matrix detection is required. Sprinkler and Halon systems are not normally installed in the same areas.	**12.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protecion/Life Safety, for more information. Automatic fire suppression may include Halon 1301 where specifically justified

guidance



guidance

6. Raised floor systems

Most equipment that requires significant cooling to maintain communication operations should be located on a raised floor system so that maximum flow of cooled air directly through the cabinets is possible. Cooling air (60^{o}F) supplied directly into the base of the transmitters will leave the top at approximately 72^{o}F. When the air exits the equipment, it is at a more comfortable temperature for personnel working in the space.

9. Equipment area

Fixtures should be arranged above the operating aisles, running parallel to equipment row arrangements. They should be located so as not to cast shadows or reflections on the front of the technical equipment or to be obstructed by the cable trays. Flush-mounted fluorescent lighting fixtures are recommended, and they shall be equipped with integral RF interference filters (GE no. 89G635, Sprague IF-37, or equivalent). Lights shall not interfere with access to the cable trays or equipment. (23)12 Portable task lighting should also be supplied for the equipment area at 70-to 100 footcandles.

10. Protection from moisture migration

Operating spaces that contain electronic equipment usually require close control of temperature and humidity. Vapor barriers placed under floor slabs and incorporated into roofing usually prevent moisture migration into and out of interior electronic equipment spaces. However, additional protection must be provided when exterior walls form part of the equipment space. (92)12.1-13

See also Vol 2, SB2, Special Mechanical.

guidance

Air-conditioning

Continuous, reliable operation of computer systems depends on an efficient, well designed, properly controlled air-conditioning system. Lack of adequate cooling contributes as much to failure as poorly regulated power. (74) 4-17

Even though certain individual units can operate outside the limits of the overall specifications, the system's environmental requirements are dictated by its most restrictive unit. Computer system requirements are the major considerations in air-conditioning system design. However, good design will also consider personnel comfort. (74) 4-17

An air-conditioning system for a computer installation differs from ordinary comfort air-conditioning in the following ways: (74) 4-17

- Heat dissipation by the computers is relatively constant; therefore, year-round cooling is required.
- The computer room sensible heat ratio is near unity because all heat dissipated by the computer system is sensible.
- Above-average air filtration is required to prevent errors caused by dust particles on magnetic tapes.
- The number of air changes per hour varies between 30 and 60 because of the computer equipment's high heat dissipation.
- Year-round humidity control is required to maintain necessary conditions in the computer room. However, introducing water vapor into the airstream for humidification is not recommended in electronic equipment areas because this can cause damage. (40) 7-3

Temperature and humidity recording instruments

Recording instruments are required to provide a continuous record of temperature and humidity in the machine area. Also, if the air-conditioning requirements are not met, a record is available to indicate the extent and duration of the undesirable condition and to show whether a drying-out period is required. In some cases, this may save machine shutdown time. (74) 4-25

The record of temperature and humidity can be used to: (74) 4-25

- Insure that the air-conditioning installation continues to perform its job properly. Installation errors and loss of efficiency due to malfunction of some air-conditioning system part can be detected quickly.
- Determine if a drying-out period is necessary when humidity limitations are exceeded. Drying-out may be needed if the excess humidity occurs either during actual system operation or when the machine is shut down and unattended. The extent and duration of the excess humidity is used to determine the length

guidance

of the drying-out period.

- Determine if the environment in the area meets the requirements for the machine.

A visual or audible signal in the instrument is desirable to indicate when temperature or humidity in the computer area is nearing maximum limit.

Direct-reading instruments with a 7-day electric-drive chart are sometimes used to monitor ambient room conditions in installations. The recorder is usually located at a representative point in the room and adjacent to the control devices.

A remote indicating instrument is recommended for monitoring the underfloor air. This is usually a 7-day electric-drive chart and can be the wet-and-dry bulb or electronic type if direct reading is not available. This instrument can be located on the wall in the room, in the mechanical equipment room, or at any other location convenient to the building engineer.

guidance

10. Supply/exhaust system

Air-conditioning input to transmitters is dedicated to each unit. Input is from below, as shown in Figure HF-1. An alternative source of air should also be available.

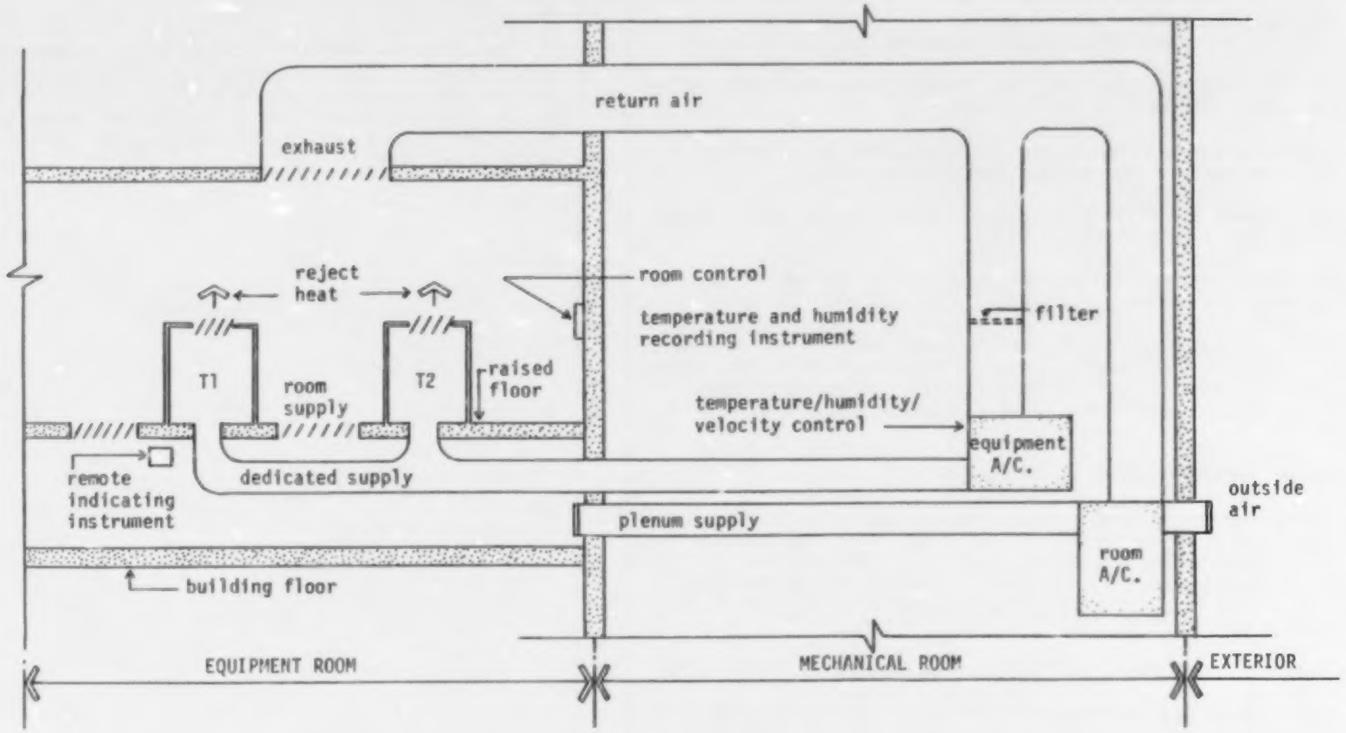
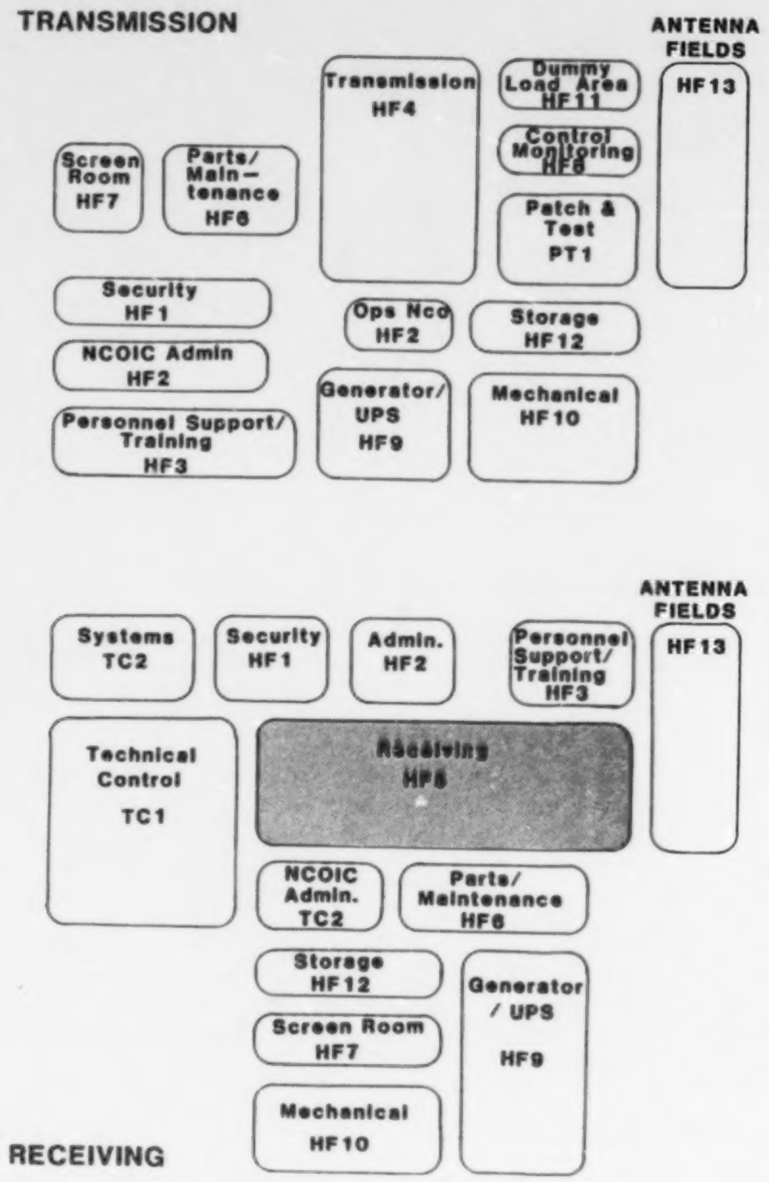

return air
exhaust
reject heat
room control
temperature and humidity recording instrument
filter
T1
room supply
T2
raised floor
temperature/humidity/velocity control
equipment A/C.
remote indicating instrument
dedicated supply
outside air
plenum supply
room A/C.
building floor
EQUIPMENT ROOM
MECHANICAL ROOM
EXTERIOR

FIGURE HF-1. AIR-CONDITIONING INPUT TO TRANSMITTERS.

guidance

guidance

RECEIVING HF5


TRANSMISSION
ANTENNA FIELDS
Transmission HF4
Dummy Load Area HF11
Control Monitoring HF8
Patch & Test PT1
HF13
Screen Room HF7
Parts/ Main-tenance HF6
Security HF1
NCOIC Admin HF2
Personnel Support/ Training HF3
Ops Nco HF2
Storage HF12
Generator/ UPS HF9
Mechanical HF10
ANTENNA FIELDS
HF13
Systems TC2
Security HF1
Admin. HF2
Personnel Support/ Training HF3
Technical Control TC1
Receiving HF5
NCOIC Admin. TC2
Parts/ Maintenance HF6
Storage HF12
Generator / UPS HF9
Screen Room HF7
Mechanical HF10
RECEIVING

function

This area contains the equipment that receives HF communications and other information.

policy/sop

issues and assumptions

1. Automated recordkeeping

CRTs with hardline printers can streamline paperwork by storing all circuit history files on disk. This will allow more rapid troubleshooting in-house.

2. Electromagnetic compatibility (2) 5-43

Electromagnetic compatibility (EMC) is a complex subject, so that specialists often must perform the type of EMC study needed to insure the equipment or equipment layout produces no interferences or radiation hazard.

DOD is working on new regulations to control permissible levels of EM pollution of the frequency spectrum. This work reflects the concern for environmental protection. Radiation hazards also are being regulated through concern for occupational safety. Engineering agencies working for the Government must therefore know the legal and regulatory aspects of EMC and radiation hazards to meet these requirements.

Military specifications on EMC such as MIL-STD-461, -462, and -463 are intended to control and achieve an acceptable quality in the development of new communications equipment. They do not eliminate the need for EMC engineering in facility design. In addition to equipment quality, the frequency selection, nearness to other facilities and, to some extent, the facility design itself are variables in the interference generation problem. (2) 5-43

3. Determining the correct shielding procedure

A comprehensive approach to the shielding of equipment from radio-frequency interference (RFI) or TEMPEST involves (a) a building layout to optimize inherent facility shielding conditions, (b) suitable location of all electronic equipment and signal cables, and (c) selection of effective shielding materials and construction components.

See Vol 2, SB4, for additional guidance information.

activities

1. Monitoring transmission equipment.
2. Testing and maintaining transmission equipment.
3. Recording maintenance work.
4. Logging in transmission data.

personnel

1. Two maintenance technicians.

equipment*

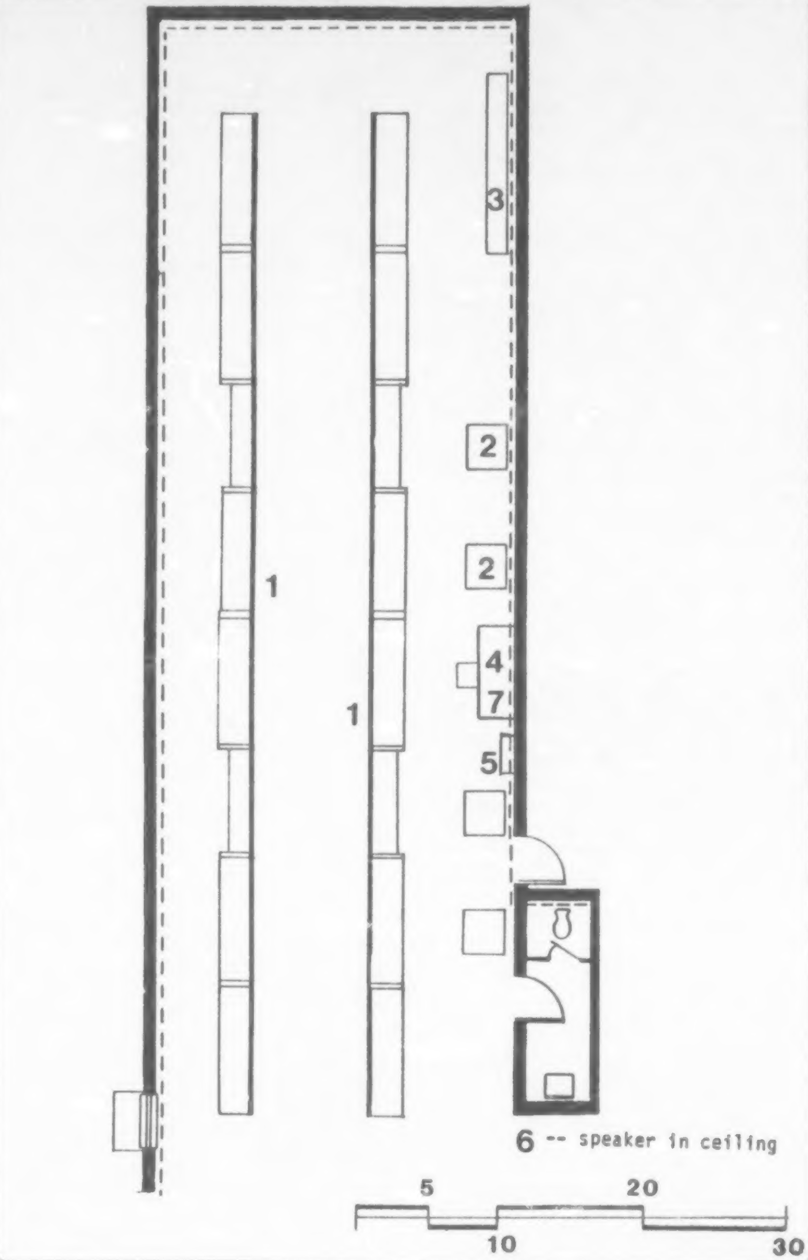
1. Receiving equipment.
2. Carts for equipment.
3. Shelves for manuals (12 linear feet).
4. CRT at desk.
5. Alarm panel.
6. Intercom.
7. Telephones.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to operate and monitor C-E equipment. Space must be allowed for proper spacing between equipment to facilitate easy maintenance.	**1.** Space requirements vary with the communication equipment design. See Guidance layout.	
2. Security for C-E equipment.	**2.** The operations room must be lockable when unstaffed and supplied with an intrusion alarm system. The operations console should be fitted with alarms for intrusion, power failure, and generator status.	**2.** See Vol 2, SB7, Security (Zone 3), for more information.
3. Monitor for building systems.	**3.** Provide a monitor panel for general and communication power, including the environmental control unit (ECU).	
4. Signal shielding.	**4.** This space must be shielded against the emanation of signal transmissions or all appropriate equipment in the space must be TEMPEST certified.	**4.** See SB4, Grounding, Bonding, and Shielding, along with Vol 2, SB7, Security (Zone 3) for more information.
5. EMP/HEMP shielding.	**5.** Provide shielding for survivability and uninterrupted function during EMP and HEMP events. Protective measures are based on intercepting the incident energy and dissipating it or reflecting it away from the threatened device, equipment, or facility.	**5.** See Vol 2, SB5, EMP/HEMP Protection, for more information.
6. Raised floor system.	**6.** Install raised or false floors for proper cooling of the equipment.	**6.** See also Vol 2, SB2, Communication Station Buildings--Architectural.
7. Interior finishes suitable for durability, maintenance, and room function.	**7.** Floor--Vinyl asbestos tile and wall-to-wall carpet in main traffic areas. A raised floor system shall be used over a concrete floor with a dusted-on finish that contains a hardener. See Vol 2, SB2 Interior Construction. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster and acoustic tiles to within 4 feet of the floor. Ceiling--Acoustic tile.	**7.** See also Vol 2, "Site and Building Information," SB2, Interior Construction and Finishes.
8. Acoustical isolation and attenuation for variable noise levels produced by electronic equipment.	**8.** Adjacent room walls should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .50 (minimum) and floor surface at NRC .25 (minimum). Acoustic tile is also required to within 4 feet of the floor.	
9. Adequate lighting.	**9.** Ambient lighting--20 footcandles. Task lighting--70 to 100 footcandles for testing and inspection.	

requirements	criteria	commentary
10. Environmental control for proper operation of electronic equipment.	**10.** Provide temperature regulation at 70°F ($\pm 2^{\circ}$) with 50 percent relative humidity (± 5 percent) continuously. Outside air ventilation rate should be 5 cubic feet per minute per person or the outside air quantity necessary to maintain a room pressurization requirement of .05 to .10 H_2O.	**10.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
11. Electrical power.	**11.** Install 120/208 electrical service. Use 120-volt outlets--one receptacle for every 10 linear feet of wall. Outlets for equipment must be available under the raised floor in accordance with the layout. Electrical power must fall within the 10,000 to 500,000-watt range. Frequency levels should be 50 to 60 hertz ± 5 percent.	**11.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
12. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**12.** Vaulted enclosure walls--2-hour (minimum) fire-rated shielded construction. Interior doors in vaulted walls--1.5-hour fire-rated doors; shielded doors and frames. Interior finish--Class A or B only. Automatic fire detection--Local alarm. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility. Provide manual emergency equipment power shut-off at exits. Under raised floor area--Automatic fire detection: Local alarm. Use an automatic Halon 1301 suppression system if cross-zoned or matrix detection is required. Sprinkler and Halon systems are not normally installed in the same areas.	**12.** See Vol 2, Standardized Modules--Building Design Principles, and SB3, Fire Protection/Life Safety, for more information. Automatic fire suppression may include Halon 1301 where specifically justified

guidance



guidance

6. Raised floor system

Most equipment that requires significant cooling to maintain communication operations should be located on raised floors for maximal use of coupled air directly through the cabinets. Cooling air at 60°F supplied directly into the base of the transmitters will leave the top at approximately 72°F. Thus, when the air exits the equipment, it is at a more comfortable temperature for persons working in the space.

9. Control area

Light fixtures should provide an approximate uniform lighting intensity of 70 footcandles and should be equipped with light control lenses or specular parabolic louvers to minimize glare on working surfaces. Lights over the area in which the control console is located shall be provided with wide-range (100:1) dimming control. (23)12

Equipment area

Fixtures should be arranged above the operating aisles and should run parallel to equipment row arrangement. They should be located so the light does not cast shadows or reflections on the front of the technical equipment and so light is not obstructed by the cable trays. Flush-mounted fluorescent lighting fixtures are recommended, and they shall be equipped with integral RFI filters (GE no. 89G635, Sprague IF-37, or equivalent). The lights shall not interfere with access to the cable trays or equipment. (23)12 Portable task lighting should also be supplied for the equipment area at 70 to 100 footcandles.

10. Protection from moisture migration

Operating spaces that contain electronic equipment usually require close temperature and humidity control. Vapor barriers placed under floor slabs and roofing usually prevent moisture migration into and out of interior electronic equipment spaces. Additional protection must be provided if exterior walls form part of the equipment space. (92)12.1-13

See also Vol 2, SB2, Special Mechanical.

guidance

Mechanical

The recommended operating temperatures and humidity conditions should be obtained from the manufacturers of the communications and data processing equipment and should be used in designing the environmental control system.

Air-conditioning

Continuous, reliable operation of any computer system depends on an efficient, well designed, properly controlled air-conditioning system. Inadequate cooling contributes as much to failure as poorly regulated power. (74) 4-17

Even though certain individual units can operate outside the limits of the overall specifications, overall environmental requirements are dictated by the most restrictive unit of the system. The computer system's requirements are the major considerations; however, good design will also consider personnel comfort. (74) 4-17

An air-conditioning system for a computer installation differs from ordinary comfort air-conditioning in the following ways. (74) 4-17

- Heat dissipation by computers is relatively constant; therefore, cooling is required year-round.
- The computer room sensible heat ratio is near unity because heat dissipated by the computer system is all sensible.
- Above-average air filtration is required to prevent errors caused by dust particles on magnetic tapes.
- The number of air changes per hour varies between 30 and 60 because of the computer equipment's high heat dissipation.
- Humidity control is required year-round to maintain necessary conditions in the computer room. However, introducing water vapor into the airstream for humidification is not recommended for electronic equipment areas because water vapor can damage electronic components. (40) 7-3

Temperature and humidity recording instruments

Recording instruments are needed to provide a continuous record of temperature and humidity in the machine area. Also, if the air-conditioning requirements are not met, a record must be available to indicate the extent and duration of the undesirable condition and indicate whether a drying-out period is required. In some cases, this may save machine shutdown time. (74) 4-25

The record of temperature and humidity can be used to: (74) 4-25

guidance

- Insure the air-conditioning system continues to perform its job properly. Installation errors and loss of efficiency due to malfunction of some air-conditioning system part can be detected quickly.
- Determine if a mandatory drying-out period is needed when humidity limitations are exceeded. Drying out may be necessary if the excess humidity occurs either during periods of actual operation or while the machine is shut down and unattended. The extent and duration of excessive humidity determines the length of the drying-out period.
- Determine if the environment meets requirements for the machine.

A visual or audible signaling device is desirable in the recording instrument. This is to provide visual or audible indication that temperature or humidity in the computer area is nearing the maximum limit.

Direct-reading instruments with a 7-day electric-drive chart are sometimes used in installations to monitor ambient room conditions. The recorder is usually located at a representative spot in the room and adjacent to the control devices.

For monitoring underfloor air conditions, a remote indicating instrument is recommended. This is usually a 7-day electric-drive chart and can be the wet-and-dry-bulb or electronic type if direct reading is not available. The recording instrument can be located on the wall in the operations room, in the mechanical equipment room, or in any other location convenient to the building engineer.

11. Electrical

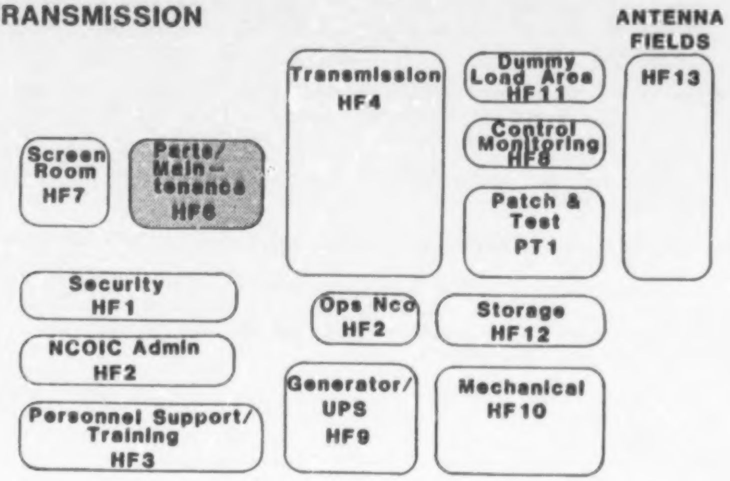
Consider providing a flexible system that will meet the facility's future requirements. Electronic equipment is constantly being upgraded, modified, and replaced. Bus duct systems and cable trays may prove to be most flexible for areas in which new equipment is expected or that may have frequent modification. (5) 3-4-8. A recommended expansion capacity of 40 percent is usually provided.

Specifically refer to the "Electrical" portion of "Issues and Assumptions" portion of SB2, Vol. 2, for information relative to host nation power requirements. Additional information may be found in "guidance" of SB2 with respect to the standard frequencies and voltage levels used by various nations.

Provide host nation standard outlets if applicable.

PARTS /MAINTENANCE HF6

TRANSMISSION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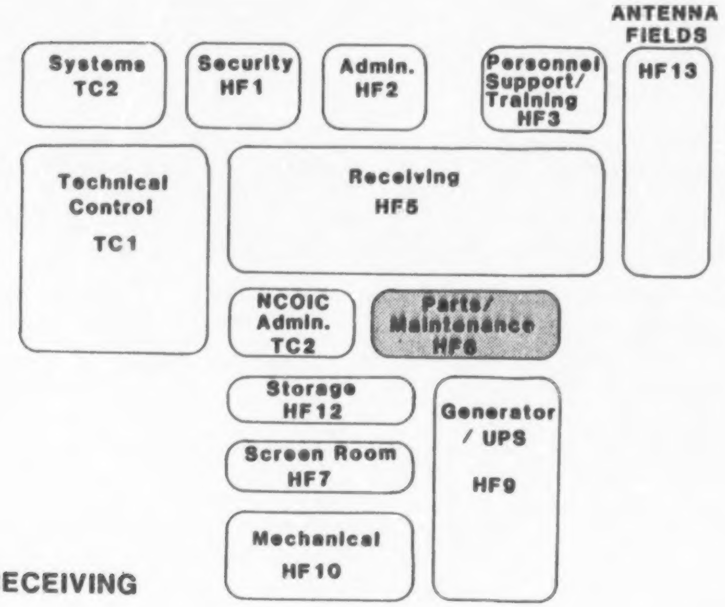
HF13
Transmission HF4
Dummy Load Area HF11
Control Monitoring HF8
Patch & Test PT1
Screen Room HF7
Parts/ Main-tenance HF6
Security HF1
NCOIC Admin HF2
Personnel Support/ Training HF3
Ops Nco HF2
Storage HF12
Generator/ UPS HF9
Mechanical HF10


ANTENNA FIELDS
HF13
Systems TC2
Security HF1
Admin. HF2
Personnel Support/ Training HF3
Technical Control TC1
Receiving HF5
NCOIC Admin. TC2
Parts/ Maintenance HF6
Storage HF12
Screen Room HF7
Generator / UPS HF9
Mechanical HF10

RECEIVING

function

This area is for assigned personnel and the shift supervisor who repair, clean, and test communication equipment.

It also supplies the space required to manage all parts supply operations: ordering, receiving, storage, inventory, and security.

policy/sop

Maintenance

1. It is desirable to provide a separate maintenance room with space for repair activities and the associated test equipment and tools. The space required will, of course, depend on the amount of C-E equipment installed, the number of maintenance personnel involved, and requirements for stocking spare parts.

2. To test and service a microwave communications system properly, maintenance personnel should have a thorough understanding of the equipment's physical makeup, operational characteristics, capabilities, and limitations, and should be familiar with the circuit theory of operation. It is equally important that the proper test equipment be available to these personnel. As the area of maintenance progresses from onsite field maintenance to depot maintenance, the quantity and requirements of the associated test equipment will increase, necessitating improved facility responsiveness. (70) 7-51

Parts

1. Requirements for spare parts storage space are determined by the type of equipment at the installation and the level of maintenance to be performed onsite.

2. During preventive maintenance inspections, it may be noticed that some components' performance has deteriorated. Rather than wait for the component to become weaker or to fail completely and cause system interruption, it is considered good maintenance practice to replace the faulty parts during the inspection. Although components would be replaced before their full service life has been realized, service interruptions could be avoided. This practice would, in turn, increase the expected replacement parts cost for an operating system; however, the increase would be justified on the basis of increased system reliability and savings for additional manpower costs that would be incurred in making special trips to unattended stations to restore system operation. (70) 7-49

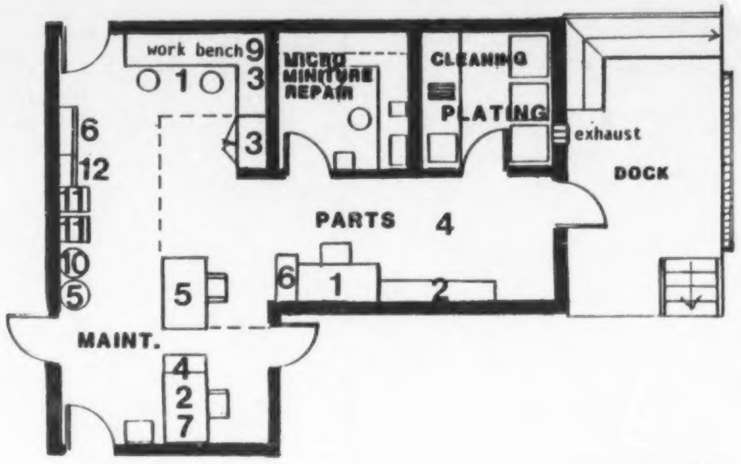
activities	personnel	equipment *
Maintenance		
1. inspecting and diagnosing equipment and parts. 2. Completing preventive and unscheduled maintenance. 3. Assembling electronics. 4. Testing electronics. 5. Securing storage of parts and equipment. 6. Maintaining records on parts and equipment. 7. Writing and typing reports, PMI 349's, and equipment historical records.	1. Shift supervisor 2. One or two specialists.	1. One electronic workbench with stool . 2. One desk with chair. 3. Shelving over workbench for publications. 4. File cabinet. 5. Portable vacuum cleaner to clean equipment parts. If compressed air blower unit is supplied instead, use 30 pounds per square inch maximum to prevent damage to parts. (Use with a dust collector.) 6. Locked storage cabinets secured to wall for special electronic equipment. 7. Typewriter or word processor. 8. Intercom speaker. 9. Wall-mounted test equipment over workbench. 10. Portable power supply test set. 11. Two scope carts. 12. Multiboard (24 by 48 inches). 13. Telephone. * see "guidance" box for example layout of all equipment listed.

activities	personnel	equipment *
Parts		
1. Developing parts order lists and working with station Central Supply Office. 2. Receiving, unpacking, shelving of prescribed load list and facility supply parts. 3. Packing and shipping repairable items.	1. One supply specialist.	1. Table (30 by 60 inches) with chair. 2. Shelving-- 6 linear feet, floor-to-ceiling type. 3. One locked cabinet (24 by 36 inches). 4. Open area (100 square feet) for unpacking orders. 5. Desk with chair for parts ordering, microfiche unit. 6. Bookcase for supply manuals--3 to 4 linear feet. * see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for inspection, disassembly, and assembly of sensitive electronic equipment. Space must also be allowed for administrative, tool, and part needs.	1. Provide approximately 900 square feet. HF receiving facilities require separate rooms for both micro-miniture repair work and electronic parts cleaning and plating.	
2. Security for equipment and materials.	2. Doors must be lockable when the room is unstaffed.	
3. Monorail hoist.	3. Provide a 1-ton monorail hoist for easy transport of communication equipment (transmission facility only).	
4. Exhaust fan for the plating area to remove fumes and gases.	4. Provide a ventilation capacity of four air changes per hour.	4. See Vol 2, Security (Zone 3), for more information.
5. Interior finishes suitable for durability, maintenance, and room function.	5. Floor--Vinyl asbestos tile. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	5. See also Vol 2, "Site and Building Information," SB2, Interior Construction and Finishes.
6. Acoustical isolation and attenuation to eliminate C-E equipment noise, thus aiding concentration as personnel work on electronic components.	6. The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .90, floor surface at NRC .50, and divider partitions (if used) at .85.	
7. Adequate lighting.	Ambient lighting--70 footcandles. Task lighting--150 footcandles.	7. For further information on lighting design quality using the ESI concept, see Vol 2, SB2, Electrical Lighting.
8. Thermal regulation and other comforts for occupants.	Provide for temperature regulation--68°F heating and 78°F cooling, with a 5-cubic feet per minute per person outside air ventilation rate. Provide a chair with seat height adjustment, casters, swivel, and independent backrest adjustment.	8. See also Vol 2, SB2, Communication Station Buildings--Mechanical.
9. Electrical power.	9. Install 120/208 electrical service. Receptacles (120-volt) should be located for convenience at all workstations and workbenches at a suitable height for every 10 linear feet of wall. Provide four duplex receptacles at each workbench along with 220-volt receptacles when required. All equipment and workbenches must be grounded. Frequency levels should be 50 to 60 hertz ± 5 percent.	9. See also Vol 2, SB2, Communication Station Buildings--Electrical.

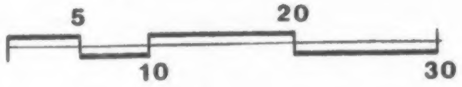
requirements	criteria	commentary
10. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**10.** Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**10.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance


work bench
9
1
3
3
MICRO MINIATURE REPAIR
CLEANING
PLATING
exhaust
DOCK
PARTS
4
6
12
11
11
10
5
5
6
1
2
MAINT.
4
2
7

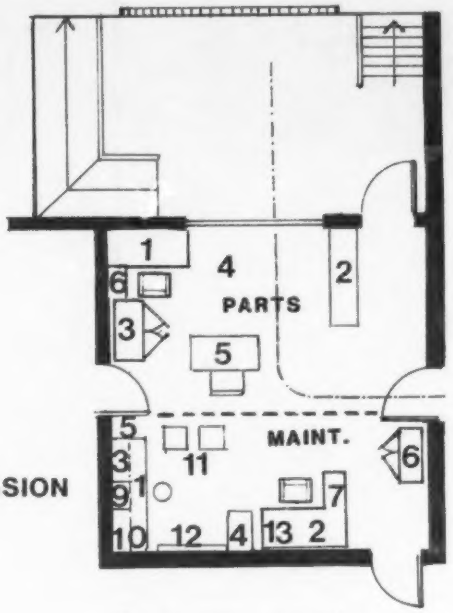
8-- speaker in ceiling

RECEIVING



guidance

TRANSMISSION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PARTS
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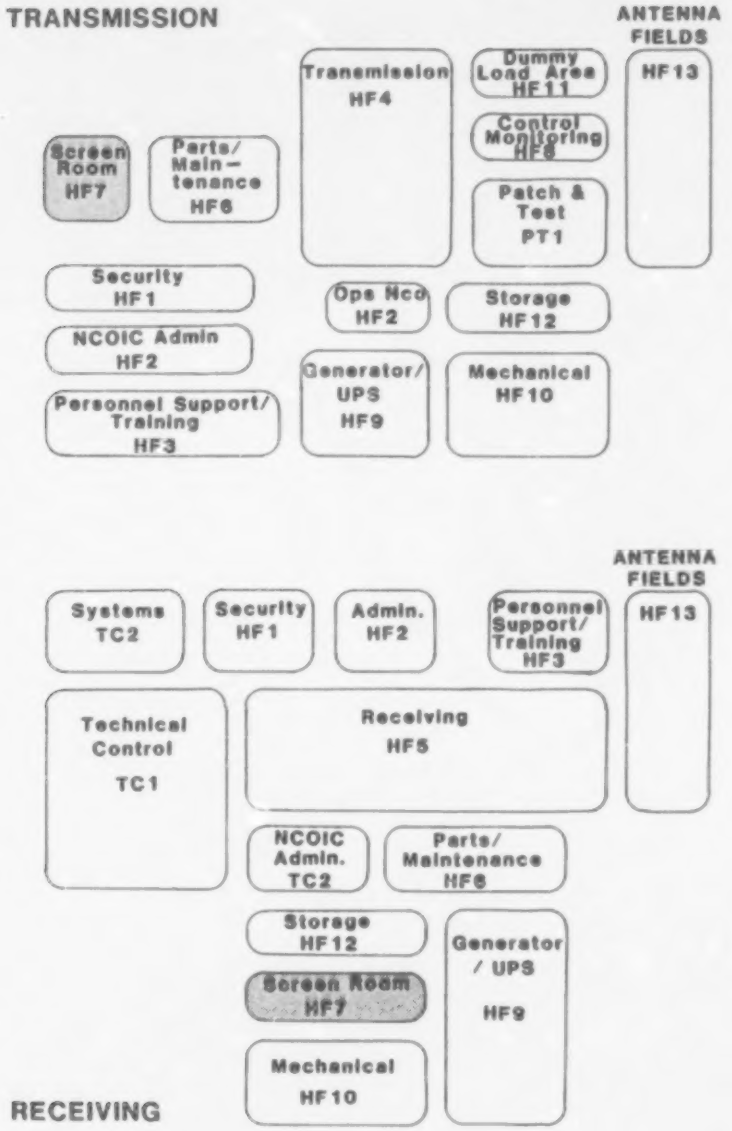
guidance

guidance

SCREEN ROOM HF7


TRANSMISSION
ANTENNA FIELDS
Transmission HF4
Dummy Load Area HF11
HF13
Control Monitoring HF8
Screen Room HF7
Parts/ Main-tenance HF6
Patch & Test PT1
Security HF1
Ops Nco HF2
Storage HF12
NCOIC Admin HF2
Generator/ UPS HF9
Mechanical HF10
Personnel Support/ Training HF3
ANTENNA FIELDS
Systems TC2
Security HF1
Admin. HF2
Personnel Support/ Training HF3
HF13
Technical Control TC1
Receiving HF5
NCOIC Admin. TC2
Parts/ Maintenance HF6
Storage HF12
Generator / UPS HF9
Screen Room HF7
Mechanical HF10
RECEIVING

function

This module is to provide an RFI-free environment for alignment and calibration of electronic equipment assemblies.

policy/sop

1. Repairs should not be done in alignment/calibration spaces; administrative functions and maintenance efforts both should be done in the maintenance area (HF6).
2. The screen room also accommodates the maintenance function in HF transmission facilities.

issues and assumptions

1. Automated recordkeeping

CRTs with hardline printers can streamline paperwork by storing all circuit history files on disk. This will allow more rapid troubleshooting in-house.

2. Electromagnetic compatibility (2) 5-43

Electromagnetic compatibility (EMC) is a complex subject, so that specialists often are needed to perform the type of EMC study needed to insure that the equipment or equipment layout produces no interference or radiation hazard.

DOD is working on new regulations to control permissible levels of EM pollution of the frequency spectrum. This work reflects the concern for environmental protection. Radiation hazards also are being regulated through concern for occupational safety. Engineering agencies working for the military must therefore know the legal and regulatory aspects of the EMC and radiation hazards to meet these requirements.

Military specifications on EMC such as MIL-STD-461, -462, and -463 are intended to control and achieve an acceptable figure of merit or quality in the development of new communications equipment. They do not eliminate the need for EMC engineering in facility design. In addition to equipment quality, the frequency selection, nearness to other facilities, and, to some extent, the facility design itself are variables in the interference generation problem. (2) 5-43

3. Correct shielding procedure

A comprehensive approach to shielding equipment from radiofrequency interference (RFI) or TEMPEST involves (a) a building layout to optimize inherent facility shielding conditions, (b) suitable location of all electronic equipment and signal cables, and (c) selection of effective shielding materials and construction components. See Vol 2, SB4, for additional guidance information.

activities

1. Inspecting and diagnosing equipment and parts.
2. Doing complete preventive and unscheduled maintenance.
3. Assembling electronics.
4. Testing electronics.
5. Insuring secure storage of parts and equipment.
6. Maintaining records on parts and equipment.
7. Writing and typing reports: 349s, and equipment historical records.

personnel

1. Shift supervisor.
2. One or two specialists.

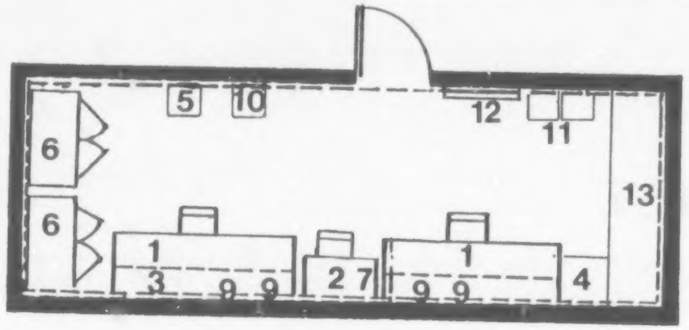
equipment *

1. Two electronic workbenches with stools.
2. Two desks with chairs, one with a typing stand.
3. Shelving over workbench for publications.
4. File cabinet.
5. Portable vacuum cleaner to clean equipment parts. If compressed air blower unit is supplied instead, use 30 pounds per square inch maximum to prevent damage to parts. (Use with a dust collector.)
6. Locked storage cabinets secured to wall for special electronic equipment.
7. Typewriter or word processor.
8. Intercom speaker.
9. Wall-mounted test equipment over workbench.
10. Portable power supply test set.
11. Two scope carts.
12. Multiboard (24 by 48 inches).
13. Telephone.
14. Shelving for inactive equipment storage.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for inspection, disassembly, and assembly of sensitive electronic equipment. Space must also accommodate administrative, tool, and part needs.	**1.** Provide approximately 300 square feet.	
2. Security for equipment and materials.	**2.** Doors must be lockable when the room is unstaffed.	**2.** See Vol 2, SB7, Security (Zone 3) for more information.
3. RFI shielding.	**3.** Provide an RFI-free environment for equipment and component testing. The room should be shielded to a predetermined attenuation level for accurate testing and calibration. The attenuation level will depend on the type of equipment being serviced.	**3.** See also Vol 2, SB4, Grounding, Bonding and Shielding.
4. Interior finishes suitable for durability, maintenance, and room function.	**4.** Floor--Vinyl asbestos tile. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster. Ceiling--Acoustic tile.	**4.** See also Vol 2, SB2, Interior Construction and Finishes.
5. Acoustical isolation and attenuation to eliminate C-E equipment noise, thus aiding concentration when personnel work on electronic components.	**5.** The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .90, floor surface at NRC .50, and divider partitions (if used) at .85.	
6. Adequate lighting.	**6.** Ambient lighting--70 footcandles. Task lighting--150 footcandles.	**6.** For further information on quality of lighting design using the ESI concept, see Vol 2, SB2, Electrical Lighting.
7. Thermal regulation and other comforts for occupants.	**7.** Provide thermal regulation of 68°F (heating), 78°F (cooling), with 5-cubic feet per minute per person outside air ventilation rate. Provide a chair with seat height adjustment, casters, swivel, and independent back rest adjustment.	
8. Electrical power.	**8.** Install 120/208 electrical service. Receptacles (120-volt) should be located for convenience at all workstations and workbenches at a suitable height for every 10 linear feet of wall. Install four duplex outlets at each workbench. All equipment and workbenches must be grounded. Frequency levels should be 50 to 60 hertz ± 5 percent. Provide line filters for RFI on all electrical power lines.	**8.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
9. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**9.** Interior finish--Class A or B only. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility. Automatic fire suppression--Water sprinklers.	**9.** See Vol 2, Standardized Modules--Building Design Principles, and SB3--Fire Protection/Life Safety, for more information.

guidance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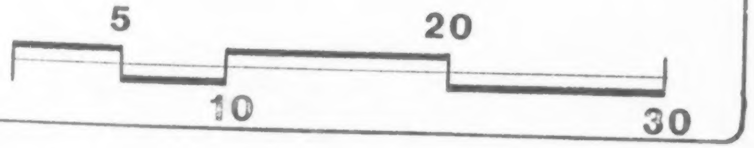
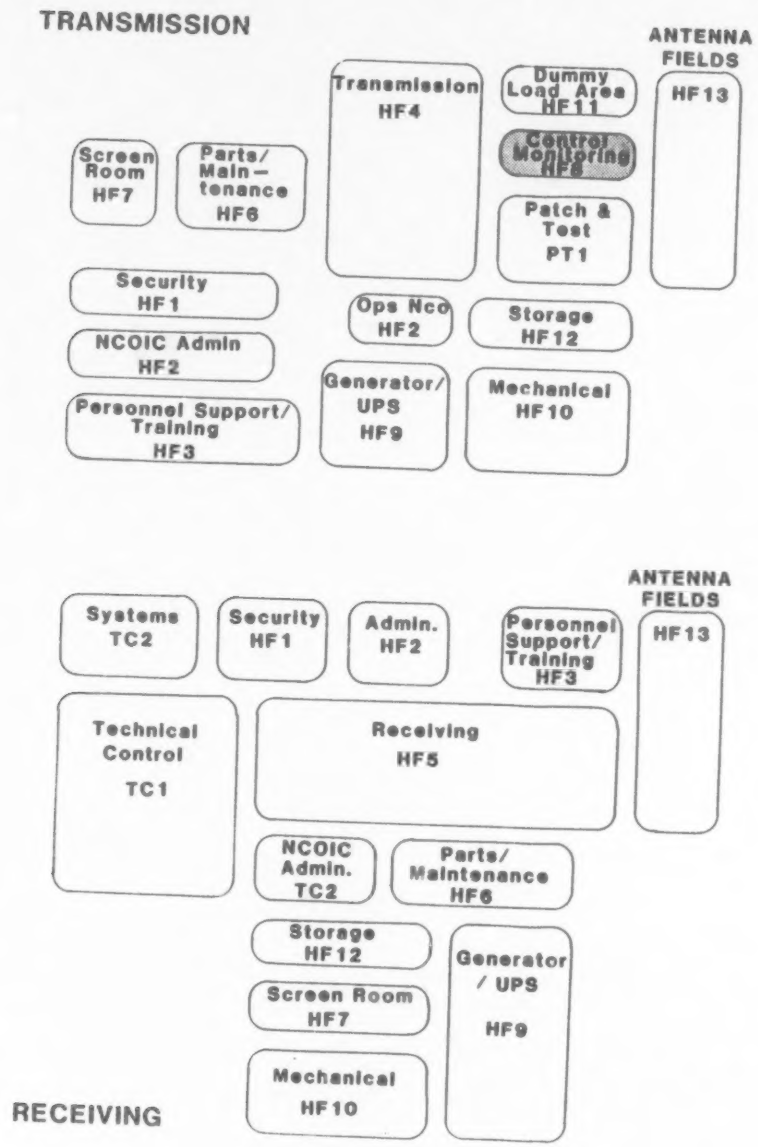
8 -- speaker in ceiling



guidance

CONTROL MONITORING HF8


TRANSMISSION
ANTENNA FIELDS
HF13
Transmission
HF4
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HF11
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Patch & Test
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Personnel Support/ Training
HF3
ANTENNA FIELDS
HF13
Systems
TC2
Security
HF1
Admin.
HF2
Personnel Support/ Training
HF3
Technical Control
TC1
Receiving
HF5
NCOIC Admin.
TC2
Parts/ Maintenance
HF6
Storage
HF12
Generator / UPS
HF9
Screen Room
HF7
Mechanical
HF10
RECEIVING

function

This module provides the required space to monitor and control the HF transmission signal quality.

policy/sop

1. To properly monitor and control an HF transmission system, operations personnel must be provided direct access to the transmission equipment room.

issues and assumptions

1. Automated recordkeeping

CRTs with hardline printers can streamline paperwork by storing all circuit history files on disk. This will allow more rapid troubleshooting in-house.

2. Electromagnetic compatibility (2) 5-43

Electromagnetic compatibility (EMC) is a complex subject, so that specialists often must perform the type of EMC study needed to insure the equipment or equipment layout produces no interferences or radiation hazard.

DOD is working on new regulations to control permissible levels of EM pollution of the frequency spectrum. This work reflects the concern for environmental protection. Radiation hazards also are being regulated through concern for occupational safety. Engineering agencies working for the Government must therefore know the legal and regulatory aspects of EMC and radiation hazards to meet these requirements.

Military specifications on EMC such as MIL-STD-461, -462, and -463 are intended to control and achieve an acceptable quality in the development of new communications equipment. They do not eliminate the need for EMC engineering in facility design. In addition to equipment quality, the frequency selection, nearness to other facilities and, to some extent, the facility design itself are variables in the interference generation problem. (2) 5-43

3. Determining the correct shielding procedure

A comprehensive approach to the shielding of equipment from radiofrequency interference (RFI) or TEMPEST involves (a) a building layout to optimize inherent facility shielding conditions, (b) suitable location of all electronic equipment and signal cables, and (c) selection of effective shielding materials and construction components.

See Vol 2, SB4, for additional guidance information.

activities

1. Monitoring transmission equipment.
2. Recording maintenance work.
3. Logging in transmission data.

personnel

1. Two maintenance personnel.

equipment *

1. Two desks with chairs.
2. Three file cabinets (five-drawer).
3. Shelves for manuals (12 linear feet).
4. CRT at desk.
5. Alarm panel.
6. Intercom.
7. Telephones.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate the control monitoring equipment and consoles. This room should be located adjacent to the transmission and dummy load spaces.	**1.** Provide approximately 250 square feet.	
2. Communication lines (outside/internal) for operations and internal interaction with the transmission and patch and test spaces.	**2.** Coordinate telephone needs between spaces.	
3. RFI shielding.	**3.** Shielding is required in electrical and electronic equipment to prevent interference propagation and to protect the equipment from the effects of interference propagated by other electronic devices. (15a)7 The term "TEMPEST" flags the system as processing national security-related information and establishes the need for additional site-specific facility alterations and improvements.	**3.** See Vol 2, SB4, Grounding, Bonding and Shielding, along with SB7, Security Systems, for more information.
4. EMP/HEMP shielding.	**4.** Provide shielding for survivability and uninterrupted functioning during EMP and HEMP events. Protective measures are based on intercepting the incident energy and dissipating it or reflecting it away from the threatened device, equipment, or facility.	**4.** See Vol 2, SB5, EMP/HEMP Protection, for more information.
5. Raised floor system.	**5.** Install raised or false floors for proper cooling of the equipment.	**5.** See also Vol 2, SB2, Communication Station Buildings--Architectural.
6. Interior finishes.	**6.** Floor--Vinyl asbestos tile. A raised floor system shall be used over a concrete floor with a dusted-on finish that contains a hardener. See Vol 2, SB2, Interior Construction. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum board, or plaster and acoustic tiles to within 4 feet of the floor. Ceiling--Acoustic tile.	**6.** See also Vol 2, "Site and Building Information," SP2, Interior Construction and Finishes.
7. Acoustical isolation and attenuation.	**7.** The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .90, floor surface at NRC .50, and divider partitions (if used) at .85.	

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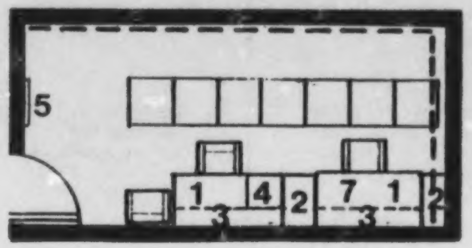
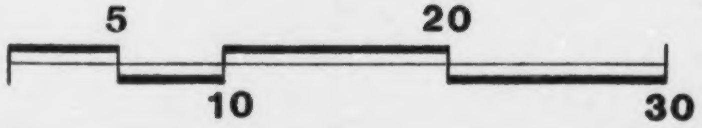
requirements	criteria	commentary
8. Adequate lighting.	**8.** Ambient lighting--20 footcandles. Task lighting--70 footcandles.	
9. Environmental control for proper operation of electronic equipment and for occupant comfort.	**9.** Regulate room at $70^{\circ}F$ ($\pm 2^{\circ}$) and 50 percent relative humidity (+ 5 percent). Outside air ventilation rate should be 5 cubic feet per minute per person or the air quantity necessary to maintain a room pressurization of .05 to .10 H_2O. Provide a chair with seat height adjustment, casters, swivel, and independent back rest adjustment.	**9.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
10. Electrical power.	**10.** Install 120/208 electrical service. Receptacles (120-volt) should be located for convenience at all workstations and workbenches at the suitable height for every 10 linear feet of wall. Frequency levels should be at 50 to 60 hertz ± 5 percent.	**10.** See also Vol 3, SB2, Communication Station Buildings--Electrical.
11. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**11.** Vaulted enclosure walls--2-hour (minimum) fire-rated shielded construction. Interior doors in vaulted walls: 1.5-hour fire-rated doors; shielded doors and frames. Interior finish--Class A or B only. Automatic fire detection--Local alarm. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility. Manual emergency equipment power shut-off at exits. Under raised floor area--Automatic fire Detection: local alarm. Use an automatic Halon 1301 suppression system is cross-zoned or matrix detection is required. Sprinkler and Halon systems are not normally installed in the same areas.	**11.** See Vol 2, Standardized Modules--Building Design Principles, and SB3, Fire Protection/Life Safety, for more information.

guidance



6-- speaker in ceiling



guidance

8. Equipment area

Fixtures should be arranged above the operating aisles running parallel to the equipment row arrangement. They should be located so the light does not cast shadows or reflections on the front of the technical equipment, and so it is not obstructed by the cable trays. Flush-mounted fluorescent lighting fixtures are recommended, and they shall be equipped with integral RF interference filters (GE no. 89G635, Sprague IF-37, or equivalent). The lights shall not interfere with access to the cable trays or equipment. (23)12. Portable task lighting should also be supplied for the equipment area at 70 to 100 footcandles.

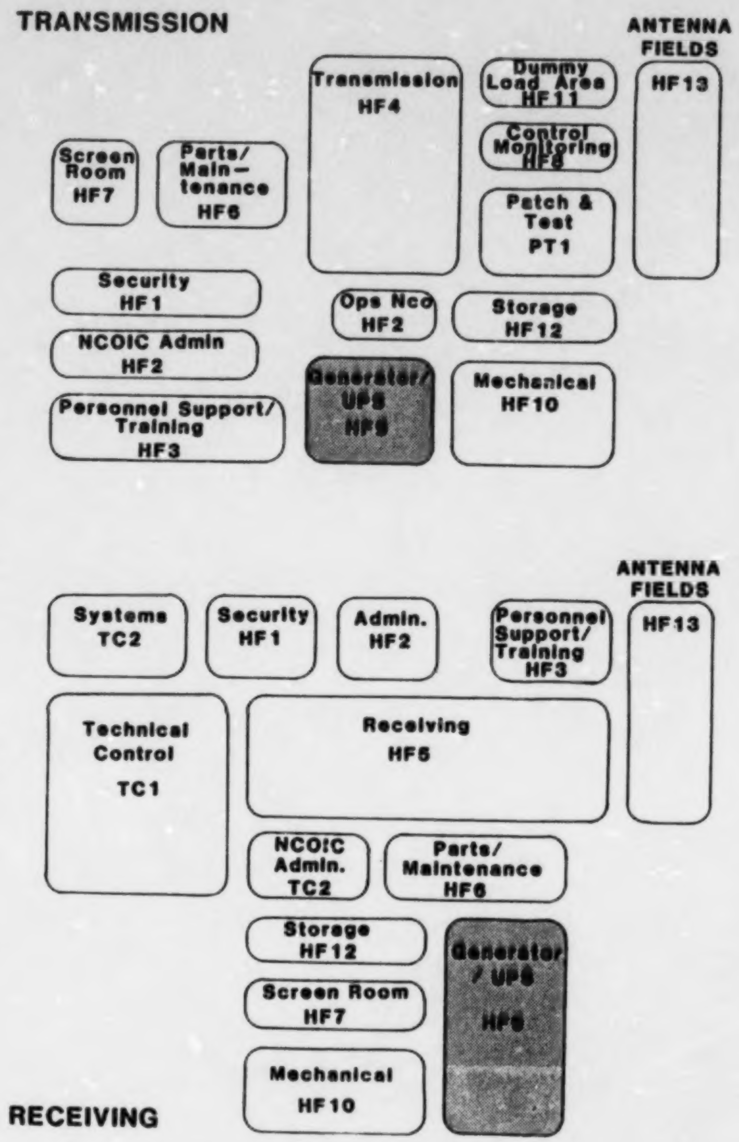
9. Protection from moisture migration

Operating spaces that contain electronic equipment usually require close temperature and humidity control. Vapor barriers under floor slabs and incorporated into roofing are usually enough to prevent moisture migration into and out of the interior electronic equipment spaces. Additional protection must be provided when exterior walls form part of the equipment space. (92)12.1-13. See also Vol 2, Special Mechanical.

guidance

guidance

GENERATOR/UPS HF9


TRANSMISSION
ANTENNA FIELDS
Transmission HF4
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Parts/Maintenance HF6
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Storage HF12
Generator/UPS HF9
Screen Room HF7
Mechanical HF10
RECEIVING

function

Facility generators maintain power to all communication systems when the commercial power fails.

An uninterruptible power supply (UPS) is designed to provide continuous power, without delay or transients, to the critical load.

policy/sop

Generators

1. Facilities usually will have three generators as a backup power source in the event of commercial power failure:

   - One generator will be online, set for automatic startup
   - Another will be backup to the first, in case of failure
   - A third generator will be considered "in maintenance" condition to be available if the backup generator fails.

   (See MIL-HDBK 411A for specific policies on the various generator classes.)

2. Primary power requirements for a communications facility are determined by the system configuration and include equipment loads (technical power), utility and domestic loads, and provisions for future expansion. The architectural engineering agency is responsible for designing the site primary power system and its distribution. One of the most economical, convenient sources of auxiliary power is the diesel-engine generator. However, an engine-driven generator requires time to start and warm up, causing a delay before taking the load after a power failure. The recommended practice is to use storage batteries to provide power instantly and economically. They are kept fully charged by the primary power source during normal operation and, when failure occurs, they assume the load instantly without interruption to service. Batteries lack the capacity to supply power for a long period of time, so it is necessary to have an auxiliary generator available. (70) 15-11

3. On-station prime power plants are considered only when the local power is either extremely unreliable or prohibitively expensive, when no power is available, or when self-sufficiency is required for survival and reliability in a wartime environment. On-station prime power plants normally use multiple sets of DOD standard family, diesel-engine generator sets for the power source. Other sources (such as wind turbines, thermoelectric generators, fuel cells, gas-turbine generators, steam-turbine generators, and nonstandard diesel-engine generators) can also be used and should be considered when requirements for a wartime DCS dictate. An onstation prime power plant will use a minimum of three engine generator sets with one set online to carry the station load, one set as a standby, and one set as a maintenance spare. A more reliable configuration is to use four or five generator sets with two online in a load-sharing mode, one as a cold standby unit and one or two as maintenance spares. When the station's standby power requirements exceed 70

policy/sop

percent of the total power requirements and the standby power is redundant, a study should be done in accordance with DOD 4270.1-M to determine if it would be more economical to provide a total energy system that produces both electrical and steam power to be used as needed. (1) 31

4. Site personnel efficiency will be improved if it is possible to locate noisy mechanical equipment, like some diesel generators, away in housing separate from working and living areas or if some other type of noise control is provided. Also, care must be taken to insure that fresh air intakes do not catch fumes or odors from sources such as diesel generators. (2) 5-25

5. All onsite power sources (generators) and substations should be located at a point in the station boundary for which security is adequate. Additional guidelines for locating power sources and substations are: (1) 32

   a. The primary onsite power source should be located far enough from the station work areas to insure acceptable noise levels as outlined by the acoustical noise requirements of MIL-STD-1472.

   b. The primary substation should be located for convenient delivery of power from an off-station source and for easy distribution of the power to onsite facilities as required.

   c. Distribution substations should be located as close as possible to the parts of the operating building they serve.

6. Total fuel storage tank capacity should be determined by local replenishment opportunities, but should hold at least a 30-day supply for primary Class A on-station generators per MIL HDBK 411A. Class C generators require a 7-day minimum supply and Class B generators require a 15-day minimum stored fuel supply. The storage tank(s) should be constructed of fiberglass and when practical, installed underground on an incline to prevent sediment accumulation. Provisions should be made for easy filling and removal of water and other sediment. (19) 13.

policy/sop

UPS

UPS are characterized by their ability to condition primary or auxiliary power to precise, high-quality power as required by the C-E equipment. UPS maintain continuous power during periods of transfer from one power source to another or for a period long enough to allow for an orderly shutdown. A UPS is required to maintain and provide continuous, conditioned power to the critical C-E equipment and to provide protection from power line transients. The UPS must have the following specific properties.

1. A UPS should serve the critical technical load. It should be solid state with batteries capable of supporting 125 percent of the critical technical load for a minimum of 15 minutes. The UPS is designed to protect equipment from disturbances of voltage and frequency inherent with conventional power distribution systems. The UPS must maintain output voltage and frequency regardless of the nature or severity of the incoming line fluctuations and/or changes in load.

2. The UPS should operate in conjunction with the existing power distribution system to provide quality power for critical technical loads. The system should consist of a solid-state inverter, a battery charger/rectifier, storage batteries, and a static transfer switch with a bypass switch.

3. During normal station operation, the UPS will be supplied with a.c. power by the primary power source; the UPS then changes a.c. power into storable d.c. electrical energy to be used as a short-term, no-break power supply for critical equipment. The UPS uses only a small amount of energy to maintain storage levels. The rest is reconverted into a.c. electrical energy. The UPS' a.c. power input and output are isolated from each other by the energy storage medium. A means should be provided to bypass the UPS completely in the event of failure or maintenance. (1)150 UPS electronic components should be in a room separate from machinery and batteries to prevent their vibration, pollution, overheating, and corrosion. See MIL-HDBK-411A for air-conditioning criteria.

   The four common types of installed UPS are:

   a. Flywheel--motor-generator
   b. Rotary
   c. Electronic
   d. Hybrid

policy/sop

4. The power sources and distribution system should be dependable, free from disturbances, and easily maintained. Efficient operation of the earth complex requires a dependable power system that minimizes the number and length of communication outages. Added to the primary objective of dependability are: (a) cost effectiveness to provide the best possible system for the least amount of money and (b) standardization to aid in cost effectiveness, maintainability, and ease of support. Additional information is available in MIL-HDBK 411A AR 420-43, NAVFAC DM-4, NAVFAC DM12.1, AFM 88-15, and the National Electrical Code. (1) 30

5. A modern solid-state UPS is a reliable source of conditioned power. The UPS usually is provided with an electronically controlled static bypass switch when input and output frequencies are identical. The static switch permits automatic bypass if the UPS fails. Also, a manual bypass switch is often provided to permit maintenance on any part of the UPS system. (1) 153 Solid-state UPS have many advantages over mechanical rotary UPS. Bearing, vibration, and low efficiency problems are avoided, and single-point failures are minimized by selection and proper configuration of solid-state UPS. Reserve battery capacity of 15 minutes is normally enough for bringing the UPS online, at which time the auxiliary power plant should be providing the input power. (19) 17

   See Vol 2, SB2, for detailed information on UPS.

issues and assumptions

1. Commercial power versus generators

The mission of DCS communication facilities is to provide reliable communications 24 hours per day. Ideally, the power source for the mission equipment should be reliable, well regulated, easily maintained, and free of transients and disturbances. In actual practice, these desirable characteristics are seldom achieved on a long-term basis. Other factors to be considered in the choice of a facility power supply are:

a. Providing the best possible system for the least amount of money (cost effectiveness).

b. Standardizing for better cost effectiveness.

c. Providing easy support (maintainability). (87) Vol 2, 62

Normally, a DCS communications facility will operate from commercial power using local generators for backup. In some areas of the world, however, commercial power may not be available or if it is, it may be so unreliable as to be unusable for the technical load. Such supplies may be satisfactory for the nontechnical load (area lighting, housing, etc.). In such cases, the primary power source should consist of generators located on the facility site. (87) Vol 2, 83

2. Comparison of engine generators

The selection of an engine generator to supply an independent power source (primary and/or standby) depends on several factors. The choice is usually between a diesel and a gasoline engine. Each has properties that determine its suitability for a particular application.

The diesel engine is suitable for either continuous or part-time service. Initial cost is slightly higher than that of a comparable gasoline engine; for certain applications, however, this disadvantage is more than offset by advantages. The diesel engine is extremely rugged, uses less and lower cost fuel, has a long life expectancy, and offers maximal reliability. Reasons for these advantages include (a) diesel fuel has a higher energy content than gasoline or liquid petroleum, (b) diesel engine operating speed is approximately half that of the gasoline engine, and (c) the diesel engine does not require an electrical ignition system. The last two factors account for lower maintenance and overhaul costs for the diesel engine. Engine starting time is comparable for diesel and gasoline engines.

Gasoline engines can be used for continuous power, but are better suited for standby use. As mentioned previously, the gasoline engine has a lower initial cost, but also a shorter life expectancy. It has a higher operating speed, which wears out the engine more rapidly. It uses more and higher operating speeds, which also wear the engine out more rapidly. It uses more and higher cost fuel and is not as reliable as a diesel engine. One reason for poor reliability is that a gasoline engine uses an electrical ignition system which is subject to failure due to dampness, age, and carbon buildup. (70) 14-3

issues and assumptions

3. Level of maintenance performed

If depot level maintenance is required and authorized, an open area, benches, and special tools (torque wrenches) also are required in the generator room. This is especially true at Navy installations, which require more extensive repair onsite.

4. Above-ground versus below-ground oil storage tank

To insure protection from hostile attack, below-ground tanks provide better security for the standby power system; however, above-ground tanks are cleaned, repaired, and maintained more efficiently, effectively, and economically.

5. Sizing generator fuel tanks

Engine generator size depends on the station's power requirements. The fuel tank capacity for these units depends on the site's accessibility and the size of the engine generators. It should not be necessary to refill fuel tanks more than once a month. If inclement weather or undue hardship dictates a longer period of time between refuelings, a larger tank is recommended. The approximate rate of fuel consumption of a diesel-driven generator, in gallons per hour, can be calculated by multiplying the output in kilowatts by 0.136; this calculation will be helpful in determining the size of tank needed. (70)
14-2

issues and assumptions

1. Selection of UPS

Single UPS--The single, static UPS has the advantage of simplicity and low cost. The single UPS configuration consists of a rectifier, an inverter, associated controls, protective devices, and an energy storage battery. This system also includes a static bypass circuit that automatically transfers the critical load to the alternate power source without an interruption to the load. When an inverter output failure is sensed, the critical load is transferred to the bypass circuit in less than 5 milliseconds. The synchronous bypass adds about 20 percent to the cost and provides eight to ten times more reliability. UPS failure causes the static switch to transfer the load to the input source, keeping the load online. When selecting this configuration, two conditions must be considered for successful operation: (a) the transfer must be fast enough that the load will not be disconnected and (b) the frequencies and voltages of the primary power and the inverter output must be the same.

Parallel redundant system--This system consists of at least two UPS operating in a load-sharing mode. The output of each is normally connected to the bus through a static interrupter for protection. If an internal fault occurs within an inverter of either system, the static interrupter isolates that inverter from the bus. In case of a bus fault, the interrupter operates in a current limiting mode until the output circuit breaker trips. Parallel UPS may be configured for various combinations of units operating in parallel, such as three units on-line with any two capable of serving the load. Parallel configuration is recommended when the frequency of the primary electric power supply must be converted to serve the critical load such as 50 to 60 hertz.

"Cold" standby independent UPS--This configuration consists of two independent UPS with a common battery. One UPS is online and the other is in "cold" standby. Both UPS are equipped with static bypass circuits that, in the event of UPS failure, automatically transfer the critical load to the primary or auxiliary power source without interruption. The second UPS is then energized manually and placed in the bypass mode and the critical load is assumed by the transfer action of the static switch. The two UPS are not intended to operate in parallel and interlock circuits are provided on the UPS output.

issues and assumptions

2. Float battery systems versus solid-state UPS

The float battery system is the most economical and reliable method of providing continuous d.c. power to critical loads. Since this system is inherently very reliable and since future power sources (renewable energy) provide d.c. power, long-range communications plans call for increased use of d.c.-powered electronics.- (19) 10

Floating battery power should be designed for optimal reliability and maximal independence of primary power abnormalities. The battery should be sized to furnish full power to the critical technical load for a period consistent with requirements and system design for auxiliary power capabilities. The battery system supporting solid-state UPS should be sized for 15 minutes in most cases. For 48-volt applications, if specific battery operation requirements are not available, the batteries should be sized for 1-hour operation at attended sites and a minimum of 8 hours' operation at unattended sites. A single float battery system should be designed for all float battery requirements in a common facility. A minimum of two rectifier chargers should be provided. The total number of rectifiers required will be determined by the number needed to supply the load and battery charging current, plus one or more for the maintenance space. When operating on commercial power, the rectifiers should be sized to provide a battery recharge-to-discharge time ratio of not more than 30 to 1. When static inverters are used, provisions should be made to transfer the load gradually from the battery to the primary or auxiliary power source. This provision, normally handled by the rectifier, will minimize transient conditions on the primary or auxiliary power source during the transfer period. (19) 22

activities	personnel	equipment **
1. Starting the on-line generators after commercial power failure. 2. Repairing and maintaining generators.	1. Two personnel, though not in room continuously.	**1.** One "set" of generators.* (Usually Class C.) **2.** Batteries for start-up. **3.** Fuel tank with dispensing pump. (Tank capacity varies with size of generators and reliability level of primary commercial power.) See MIL-HDBK 411 for the specific capacity in relationship to a class of generators. **4.** Alarm panel. **5.** Automatic transfer switches.
1. Doing prescribed maintenance and inspection (PMI) work. 2. Conducting operational checks and load tests.	1. One, though not in room continuously.	**1.** Solid-state rectifier/charger. **2.** Batteries. **3.** Inverter, synchronizing equipment. **4.** Static switches. **5.** Rotary converter (if 60-hertz equipment is used in a 50-hertz host country.

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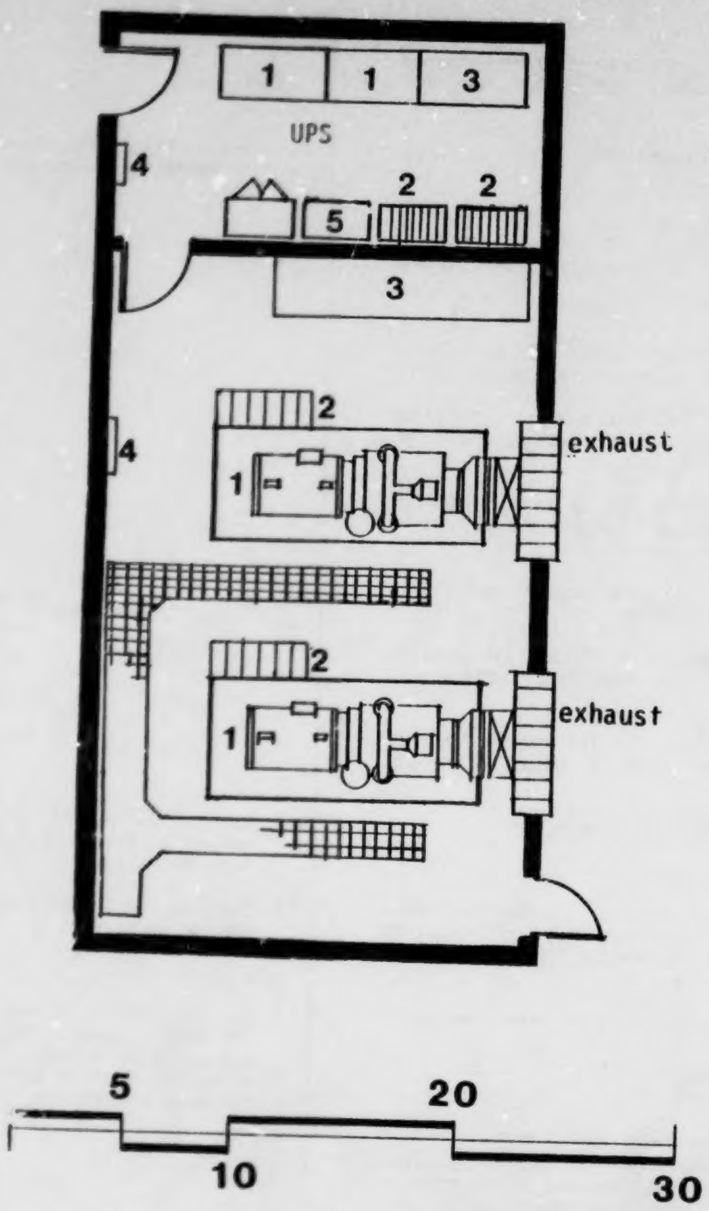
*The number and size of generators will vary among facilities depending on the voltage required to maintain the mission.

** see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for the installation, removal, and repair of standby generators.	**1.** Space needs vary with power requirements (see guidance drawing). Allow approximately 800 square feet for two generators and UPS equipment.	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustic isolation for variable noise levels produced by mechanical equipment.	**3.** Adjacent room walls should limit sound transmission to 40 decibels.	
4. Generator operation indicator and alarms.	**4.** An alarm and operation indicator panel will be located at the control console area of the operations space.	
5. Emergency lighting.	**5.** Emergency lighting should be bright enough to allow switch gear operation, instruction reading, and other mission-essential activities.	
6. Environmental control to provide generators' constant supply of make-up air for combustion and cooling.	**6.** Provide automatically adjusted louver units sized for capacity of generator selected. Exhaust stacks must be caged to prevent bird/animal entry.	
7. Vibration control.	**7.** The generators must be placed on a concrete pad physically isolated from the main floor.	
8. Design that allows complete removal and exchange of generator units.	**8.** Air intake/exhaust units should be located and sized to become a "knock-out" panel for removing a complete generator.	
9. Adequate lighting.	**9.** Use 40 footcandles (ambient). "Slow start" fixtures such as mercury vapor should not be used, nor should fluorescent fixtures.	
10. Thermal comfort.	**10.** Regulate temperature at 50°F for heating.	**10.** See also Vol 2, SB2, Communication Station Buildings--Mechanical.
11. Electrical power.	**11.** Provide 120/208 electrical service. Install 120-volt outlets; at least two duplex receptacles are required at workbench areas and at the appropriate height. Use 240-volt receptacles when required.	**11.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
12. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**12.** Interior enclosure walls--1-hour fire-rated construction. Interior doors--20-minute fire-rated. Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**12.** See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



guidance

1. Location

If a standby generator is to operate continuously for instantaneous commercial power backup, the generator room should be located away from all normal operational spaces to isolate the noise.

Clearances--All ducts and other systems installed in the facility as part of the finished structure should be arranged to maintain a 10-foot unobstructed clearance from the floor to the ceiling.

Structural--Isolate the foundations of each generator to prevent transfer of engine vibrations to the building. Floor loading should be designed to accommodate a steady load of the heaviest auxiliary diesel engine generator designed/selected by the contractor. Pad dimensions may exceed the engine dimensions by 25 to 30 percent.

Doors--All single doors should be constructed of steel and should have a minimum dimension of 4.0 by 7.0 feet. The exterior equipment door for the generator room should be double-wing type with minimum dimensions of 6.0 by 7.0 feet. This door should be equipped with a drop-in horizontal bar to secure it from the inside.

Storage tank--When required, provide an underground fuel oil storage tank adjacent to the power/mechanical room. Also provide fuel oil supply and return lines, fill pipe, oil level gage, and alarm conduits. This tank must be equipped with a float switch to activate an alarm indicating a low fuel oil condition.

A single storage tank should be provided for a minimum fuel supply for both the heating boiler and diesel engine generators. MIL HDMB 411A requires Class C generators to reserve a 7-day supply, Class B generators should reserve a 15-day supply, and Class A generators should reserve a 30-day supply. A fiberglass underground tank should be used. A day tank should be provided in the building to supply fuel to both the heating boiler and diesel engine generators. (See also Vol. 2, SB1, Site Planning and Development).

Provide floor trenches in the power/mechanical room for supply and return fuel lines from the exterior fuel oil storage tank and for cable runs from the generator to the transfer switch and main distribution panel. Floor trenches should have 0.25-inch-thick steel plate covers.

guidance

Provide floor trenches in the power/mechanical room for supply and return fuel lines from the exterior fuel oil storage tank and for cable runs from the generator to the transfer switch and main distribution panel. Floor trenches should have 0.25-inch-thick steel plate covers.

4. Alarm system

Provide a wall-mounted alarm terminal panel in the generator room. The following alarms will be terminated there:

- Generator status
- Commercial power status
- Low fuel oil level (48-hour supply)
- High (80°F) or low (55°F) temperature status in communication equipment and power mechanical room
- Generator start failure.

The termination board or its associated housing should have all alarm terminations identified clearly with permanent marking or labels for future extensions of these connections to a control and fault alarm system. The alarm sensors should incorporate only dry contacts (no voltages) and should use two conductor shielded cables in the circuit runs or in conduit to the consolidated terminal panel noted above.

Provide adequate grounding cable from the building ring ground system, when applicable, to the diesel generator set metal frame and to the underground fuel oil storage tank. See Vol 2, SB4.

6. Environmental control

Generator exhausts should be located such that fumes will not be sucked into other HVAC air intakes. Emergency generators can be located inside the operations building if they are isolated properly from the rest of the structure in terms of fire protection, sound attenuation, and vibration control. (92) 12.1-12

Louvers and Openings

Provide motorized air damper openings in the generator room walls to accommodate diesel engine combustion air requirements.

Provide security bars on all openings subject to physical intrusion (greater than 7.6 feet in perimeter) such as air intake and exhaust louvers. Their attachment to the structure must be nonremovable from the exterior.

See Vol 2, SB7, for security guidance.

guidance

1. Location--UPS

The UPS and associated battery should be installed in separate rooms. Construction should be permanent and the wall separating the UPS should be fire-rated (see Vol 2, SB3). Continuity of power during emergency periods of power transfer is maintained by an energy storage battery. Reserve battery capacity of 15 minutes is normally long enough for UPS application, at which time the auxiliary power should be providing the input power.

Structural

Minimum Floor Load-- 250 pounds per square foot.

A clear ceiling height of 10 feet should be provided.

Doors

All doors to the UPS room should be of steel construction and should have a minimum dimension of 4.0 by 7.0 feet. Consideration may be given to installing a louvered bottom door panel on the interior door(s).

5. Environmental Control

Consideration should be given to installing solid-state UPS in an environmentally controlled room when adverse environmental conditions exist or when recommended by the UPS manufacturer.

guidance

UPS equipment areas--Figures HF-2 and HF-3 show the preferred method of heating and ventilating UPS equipment areas, as well as providing the required ventilating system redundancy. The canopy hood, also called a receiving hood, should be slightly larger than the equipment or exhaust grilles in the cabinets and should be extended fairly close to them. Direct connections should be avoided unless specifically recommended by the equipment manufacturer. Each exhaust fan should be sized to handle all air exhausted through the cabinets plus 10 percent (room air) to ensure good capture. (5) 3-3-13.

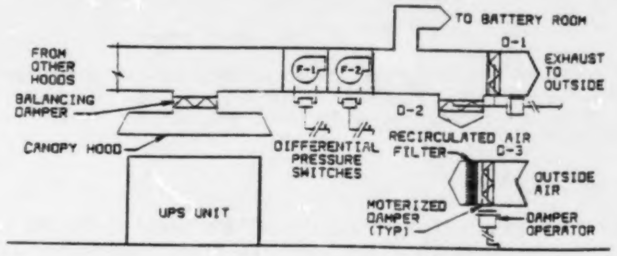

TO BATTERY ROOM
D-1
FROM OTHER HOODS
F-1
F-2
EXHAUST TO OUTSIDE
BALANCING DAMPER
D-2
CANOPY HOOD
DIFFERENTIAL PRESSURE SWITCHES
RECIRCULATED AIR
FILTER
D-3
OUTSIDE AIR
UPS UNIT
MOTERIZED DAMPER (TYP)
DAMPER OPERATOR

FIGURE HF-2. SERIES FAN ARRANGEMENT. (5) 3-3-14

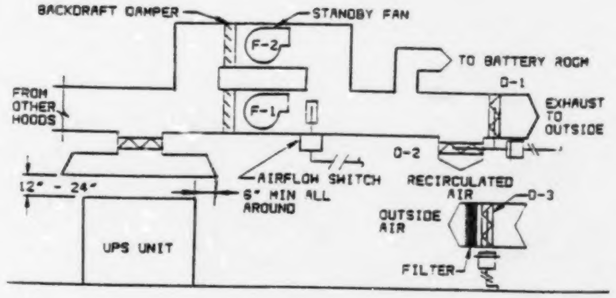

BACKDRAFT DAMPER
STANDBY FAN
F-2
TO BATTERY ROOM
D-1
FROM OTHER HOODS
F-1
EXHAUST TO OUTSIDE
D-2
AIRFLOW SWITCH
RECIRCULATED AIR
12" - 24"
6" MIN ALL AROUND
D-3
OUTSIDE AIR
UPS UNIT
FILTER

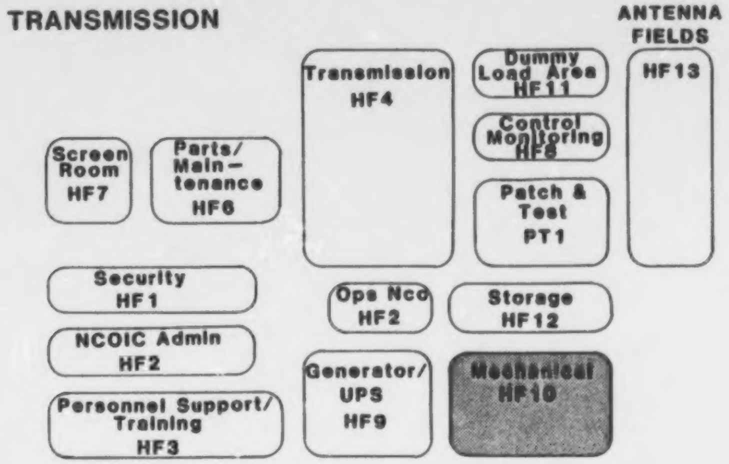
FIGURE HF-3. PARALLEL FAN ARRANGEMENT. (5) 3-3-14

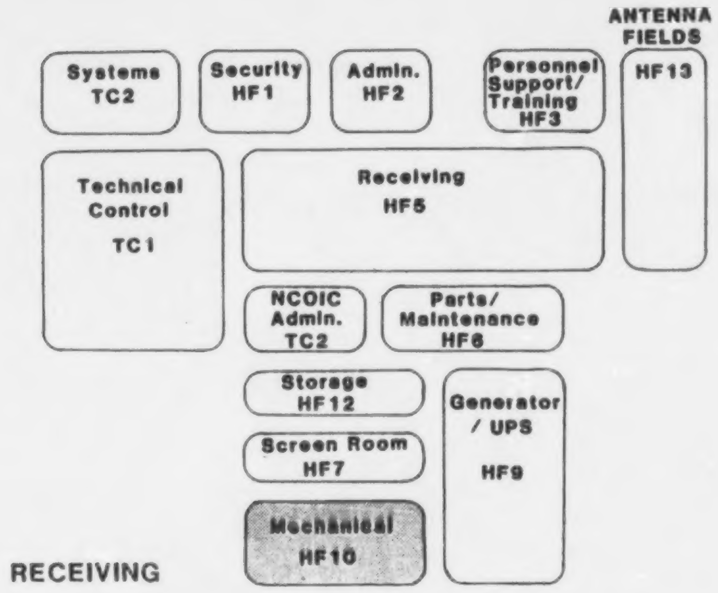
guidance

guidance

guidance

MECHANICAL HF10


TRANSMISSION
ANTENNA FIELDS
HF13
Transmission HF4
Dummy Load Area HF11
Control Monitoring HF8
Patch & Test PT1
Screen Room HF7
Parts/ Main-tenance HF6
Security HF1
NCOIC Admin HF2
Personnel Support/ Training HF3
Ops Nco HF2
Storage HF12
Generator/ UPS HF9
Mechanical HF10


ANTENNA FIELDS
HF13
Systems TC2
Security HF1
Admin. HF2
Personnel Support/ Training HF3
Technical Control TC1
Receiving HF5
NCOIC Admin. TC2
Parts/ Maintenance HF6
Storage HF12
Screen Room HF7
Generator / UPS HF9
Mechanical HF10
RECEIVING

function

This module provides space for equipment to supply all the heating, ventilating, and air-conditioning (HVAC) and water requirements for the entire facility. It must also be flexible and spacious enough to accommodate alternative energy sources.

policy/sop

1. It is desirable to provide a separate room for mechanical equipment such as heat exchangers, air-conditioners, and waveguide dehydrators-pressurizers. Heat exchangers must have air intake and exhaust ducts to the outside of the building. The size of these ducts dictates that heat exchangers must be located close to the wall. It must not be overlooked that some types of heat exchangers may require rear access for maintenance. Location of the dehydrating-pressurizing equipment is not critical. However, ease of access for maintenance is desirable and the pressure gages should be readily visible to the maintenance personnel. The air-conditioning equipment location will depend on the specific type provided and whether or not intake and outside exhaust are required. (2) 5-24

issues and assumptions

1. Calculation of space requirements

   a. Heating for each area of the facility is commonly provided by an oil-fired hot-water boiler located in the mechanical equipment room. During the heating season, hot water is supplied from the boiler to the various heating, air-conditioning, and domestic hot-water systems. In the summer, domestic hot water is provided by a small oil-fired hot-water heater and the boiler is turned off. This arrangement will add to boiler efficiency and energy conservation.

   b. Provisions will be made in the mechanical equipment rooms to allow for removal of tubes from boilers and chillers as well as the removal of coils and filters from air handling units for maintenance and replacement. All equipment will be located to allow easy access for maintenance and servicing.

   c. Usage will be 24 hours per day, 7 days per week. No special provisions for peak usage are required.

activities

1. Maintaining, controlling, and inspecting mechanical equipment.

personnel

equipment*

1. Chiller.

2. Condenser.

3. Compressor.

4. Water pumps.

5. Boiler.

6. Electrical switchboard.

7. Emergency water supply tank.

8. Day fuel tank.

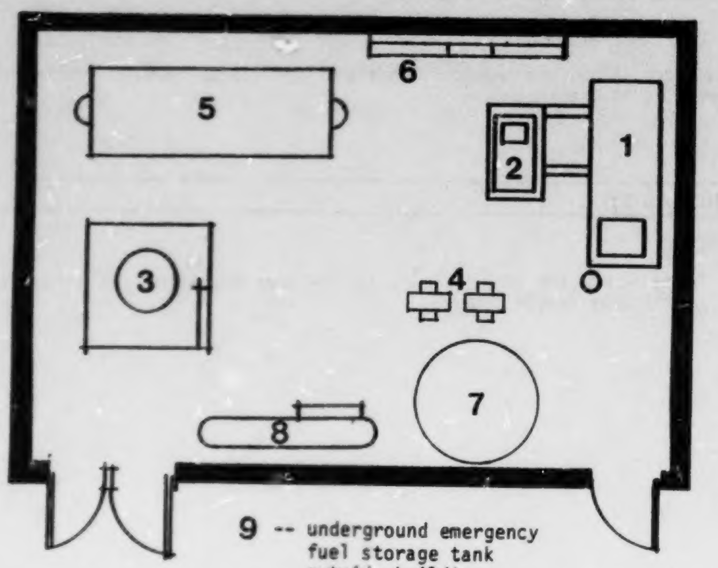
9. Emergency fuel storage tank. (Underground--see Vol 2, SB8.)

Note: Alternative energy sources may vary and alter equipment needs. See Vol 2, SB6--AES, for information.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space to accommodate the mechanical equipment requirements associated with the facility's environmental maintenance.	**1.** The ratio of mechanical equipment space to the total facility interior floor space varies from 7 percent for small facilities to about 4 percent for large facilities. (See "Issues" box.)	
2. Interior finishes suitable for durability, maintenance, and room function.	**2.** Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	**2.** See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation for variable noise levels produced by mechanical equipment.	**3.** Adjacent room walls should limit sound transmission to 40 decibels.	
4. Information display.	**4.** The operating instructions, preventive maintenance schedule, wiring and control diagrams, and detailed control sequence should be framed under glass or plastic and posted for easy reference.	
5. Water supply and sanitary sewer.	**5.** The water supply and sanitary sewer for this facility will be connected to the existing post systems or as prescribed for foreign locations. Provide an emergency water supply tank of 20-gallon per capita capacity for 7 days. Water must be refreshed periodically. See Vol 2, SB8, Survivability Protection.	
6. Adequate lighting.	**6.** Provide 40-footcandle fluorescent fixtures (ambient).	
7. Thermal comfort.	**7.** 50 to 68°F range (winter heating), except for batteries, which must be kept at 60 to 68°F.	**7.** See also Vol 2, SB2--Communication Station Buildings--Mechanical.
8. Electrical power.	**8.** Commercial electrical service used in the building will be site-specific. Availability depends on the host country if OCONUS. An outdoor transformer can be installed for the mechanical space in terms of general building power. Install 120-volt receptacles as needed. Electrical power must fall within the 10,000- to 500,000-watt range. Frequency levels should be at 50 to 60 hertz ± 5 percent.	**8.** See also Vol 2, SB2, Communication Station Buildings--Electrical.
9. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	**9.** Interior enclosure walls--1-hour fire-rated construction. Interior doors--20-minute fire-rated. Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	**9.** See Standardized Modules--Building Design Principles, Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance


1
2
3
4
5
6
7
8
9 -- underground emergency fuel storage tank outside building.

guidance

1. Storage tank

A single storage tank should be provided for a minimum 15-day supply for both the heating boiler and diesel engine generators. A fiberglass underground tank should be used. A day tank should be provided in the building to supply fuel to both the heating boiler and diesel engine generators. This tank must be equipped with a float switch to activate an alarm indicating a low fuel oil condition.

Doors--The exterior equipment doors should be steel, double swing type with steel frame. The inner opening should be at minimum 6 feet wide by 7 feet high. The equipment door should be equipped with interior locking panic hardware.

Both the exterior personnel and equipment door hinges must be welded to prevent removal of hinge pins if pivots and pins are on the outside.

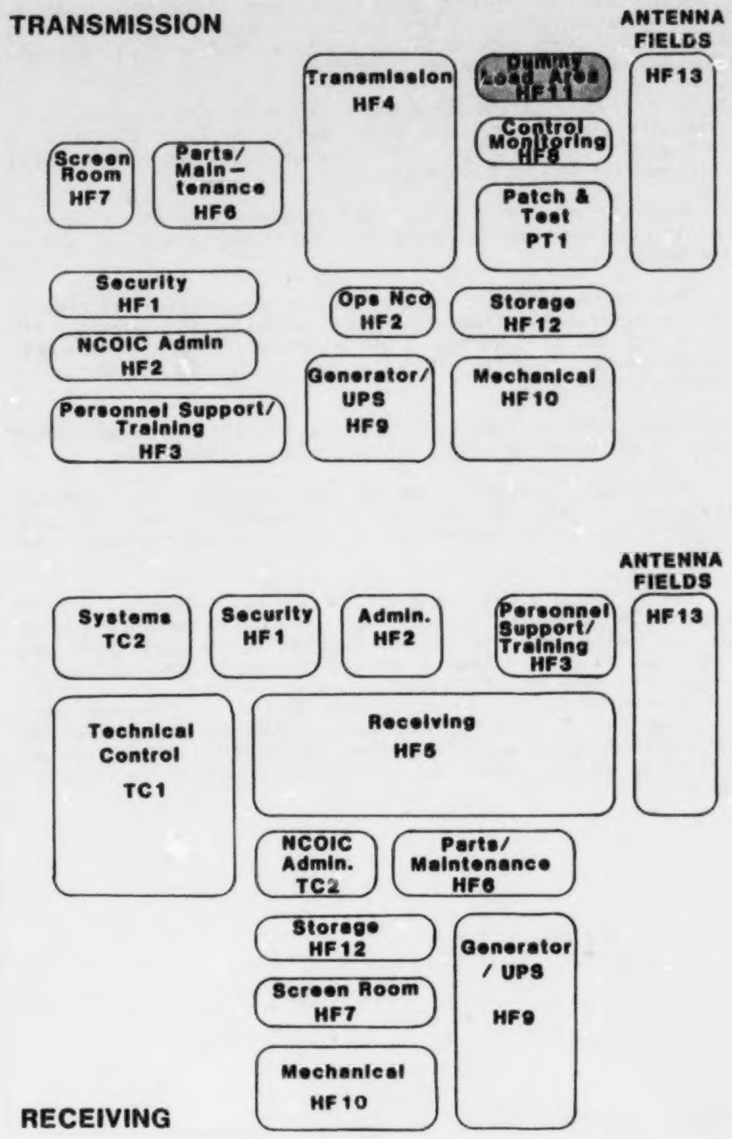
Provide security bars on all openings greater than 7.6 feet at the perimeter and subject to physical intrusion (for example, air intake and exhaust louvers). Their attachment to the structure must be nonremovable from the exterior. See Vol 2, SB7, for additional security guidance.

Structural--The minimum floor design load is 150 pounds per square foot. A clear ceiling height of 10 feet should be provided.

Mechanical equipment should be isolated to minimize vibrations. This can be done by mechanically isolating each individual system on concrete pads separate from the mechanical room floor.

Heat exchangers must be provided with air intake and exhaust ducts to the outside of the building. The size of these ducts means the heat exchangers must be located close to the wall. However, some types of heat exchangers require rear access for maintenance. Location of dehydration pressurization equipment is not critical, but ease of access for maintenance is desirable. Pressure gages should be readily visible to maintenance personnel. Location of the air-conditioning equipment depends on the specific type provided and whether intake and exhaust to the building's outside are required. (2) 5-25

DUMMY LOAD ROOM HF11


TRANSMISSION
ANTENNA FIELDS
Transmission HF4
Dummy Load Area HF11
Control Monitoring HF8
Patch & Test PT1
HF13
Screen Room HF7
Parts/ Main-tenance HF6
Security HF1
NCOIC Admin HF2
Personnel Support/ Training HF3
Ops Nco HF2
Storage HF12
Generator/ UPS HF9
Mechanical HF10
ANTENNA FIELDS
Systems TC2
Security HF1
Admin. HF2
Personnel Support/ Training HF3
HF13
Technical Control TC1
Receiving HF5
NCOIC Admin. TC2
Parts/ Maintenance HF6
Storage HF12
Screen Room HF7
Generator / UPS HF9
Mechanical HF10
RECEIVING

function

This space allows the transmission signal quality to be monitored before connecting to the antenna.

policy/sop

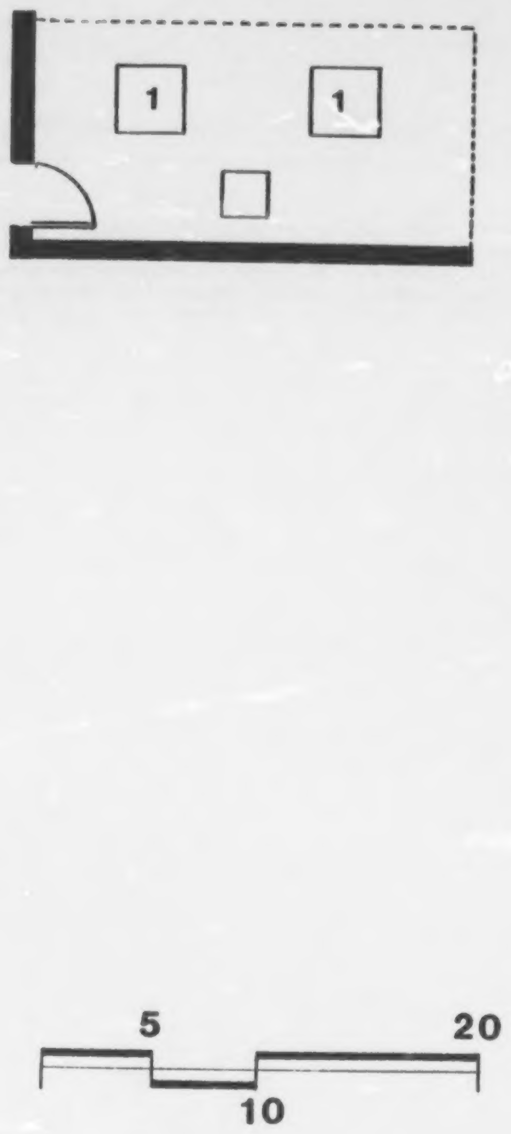
1. Dummy loads are not designed for 24-hour operation and should be operable by remote control.

issues and assumptions	activities	personnel	equipment *
	1. Monitoring HF transmission for quality of signals.	1. One technician, though not in room continuously.	1. Dummy load equipment.

* see "guidance" box for example layout of all equipment listed.

requirements	criteria	commentary
1. Enough space for performance of scheduled and unscheduled maintenance.	1. Provide approximately 200 square feet of exterior surface area protected from the weather.	
2. Enough ventilation to insure heat dissipation during heavy, prolonged use (when the module is located inside the building).	2. Provide four air changes per hour.	
3. Interior finishes suitable for durability, maintenance, and room function (when the module is located inside the building).	3. Floor--Vinyl asbestos tile. Base--Glazed structural units, rubber, vinyl, or comparable resilient material. Walls--Paint over concrete, gypsum boards, or plaster. Ceiling--Acoustic tile.	3. See also Vol 2, "Site and Building Information," SB2, Interior Construction and Finishes.
4. Acoustical isolation and attenuation for variable noise levels produced by electronic equipment.	4. The walls around the room should limit sound transmission to 40 decibels. Ceiling material should be rated at NRC .90 and floor surface at NRC .50.	
5. Adequate lighting.	5. Ambient lighting--20 footcandles. Task lighting if applicable--100 footcandles.	
6. Thermal comfort.	6. Regulate temperature for 68°F (heating), 78°F (cooling), with a 5-cubic feet per minute per person outside air ventilation rate.	6. See also Vol 2, SB2, Communication Station Buildings--Mechanical.
7. Electrical power.	7. Install 120/208 electrical service. Receptacles (120-volt) should be located for convenience at each workstation and workbench at a suitable height for every 10 linear feet of wall. Electrical power must fall within the 10,000- to 500,000-watt range. Frequency levels should be at 50 to 60 hertz ±5 percent.	7. See also Vol 2, SB2, Communication Station Buildings--Electrical.
8. When the module is located inside, fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	8. Interior finish--Class A or B only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	8. See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

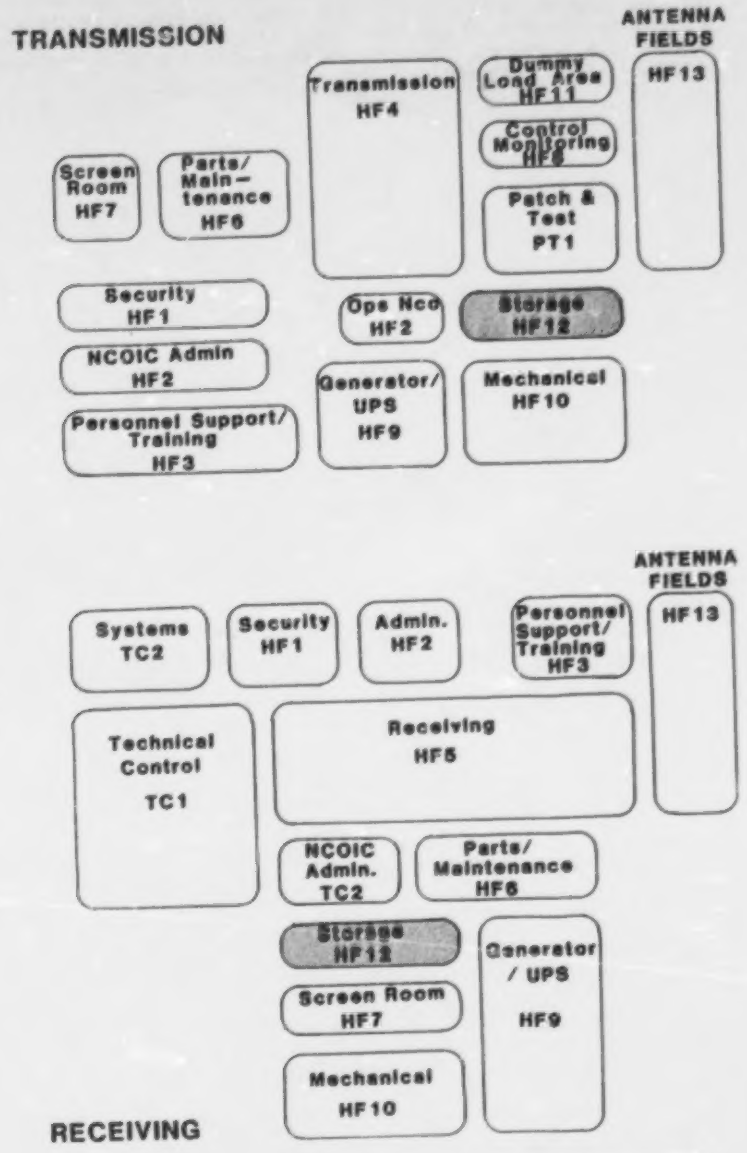
guidance



guidance

1. Dummy load equipment usually is located on a concrete pad outside the communications buildings. If the climate is adverse or the atmosphere is corrosive at the site, dummy load equipment sometimes is located in a separate, interior room to isolate the noise and heat generated by its equipment.

STORAGE HF12


TRANSMISSION
ANTENNA FIELDS
Transmission HF4
Dummy Load Area HF11
Control Monitoring HF8
HF13
Screen Room HF7
Parts/ Main-tenance HF6
Patch & Test PT1
Security HF1
Ops Nco HF2
Storage HF12
NCOIC Admin HF2
Generator/ UPS HF9
Mechanical HF10
Personnel Support/ Training HF3
ANTENNA FIELDS
Systems TC2
Security HF1
Admin. HF2
Personnel Support/ Training HF3
HF13
Technical Control TC1
Receiving HF5
NCOIC Admin. TC2
Parts/ Maintenance HF6
Storage HF12
Generator / UPS HF9
Screen Room HF7
Mechanical HF10
RECEIVING

function

This area is for the temporary placement of miscellaneous items and nontechnical equipment.

policy/sop

1. All services have physical fitness requirements that must be met. For remote DCS facilities that have no installation services available, it is recommended that exercise equipment be made available. The exacting, sometimes intense, activities of maintaining and controlling the DCS require periodic breaks for physical exercises.

issues and assumptions

1. Storage for exercise equipment

The exercise equipment should not conflict with the function of other personnel-oriented rooms. A general purpose storage room is suitable since the equipment is unofficial.

activities

1. Shelving of miscellaneous sized items.
2. Individual exercise.

personnel

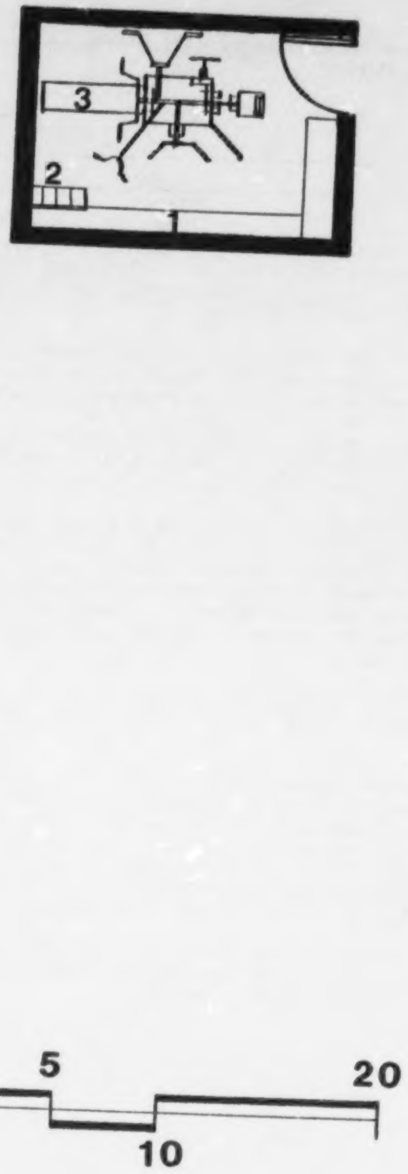
equipment*

1. Shelving 18 inches deep.
2. Small step ladder.
3. Exercycle, universal gym, and/or loose weights.

* see "guidance" box for example layout of all equipment listed.

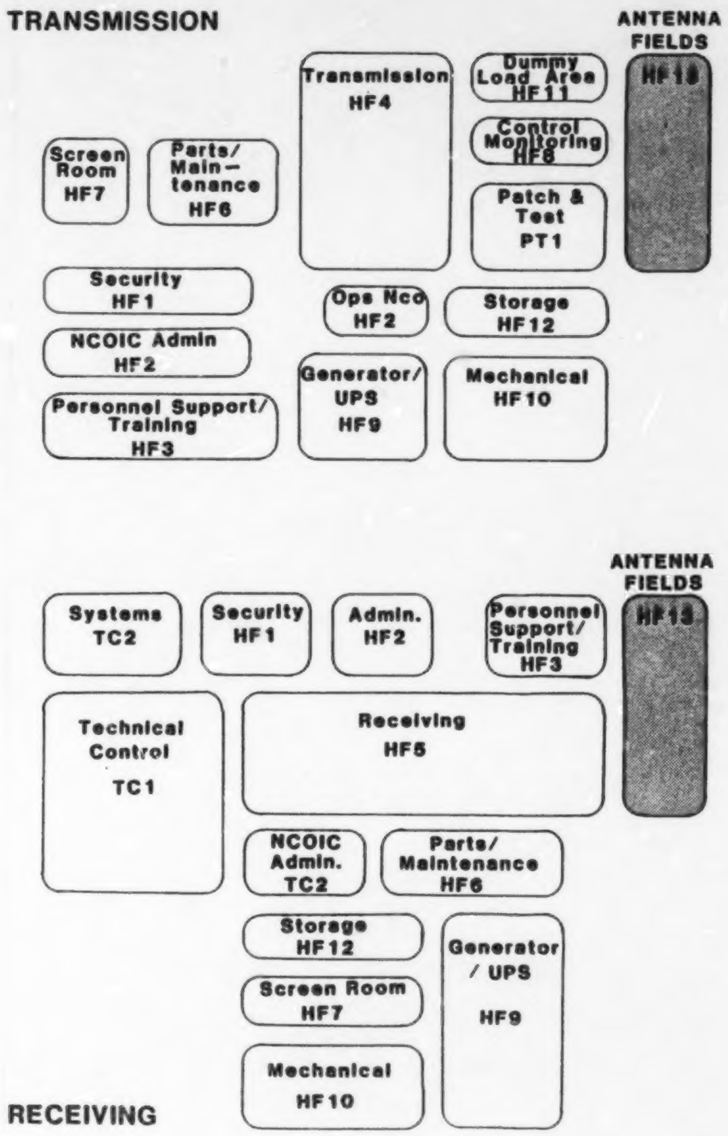
requirements	criteria	commentary
1. Enough space to accommodate two or three persons exercising, plus space to move about for shelving items.	1. Allow approximately 250 square feet to accommodate the exercise equipment plus 60 linear feet of shelf space.	
2. Interior finishes suitable for durability, maintenance, and room function.	2. Floor--Concrete, hardened and sealed. Base--Not applicable. Walls--Paint. Ceiling--Exposed and painted.	2. See also Vol 2, SB2, Interior Construction and Finishes.
3. Acoustical isolation and attenuation for a nondisruptive environment.	3. Adjacent room walls should limit sound transmission to 40 decibels.	
4. Adequate lighting.	4. Use 30-footcandle (ambient) fluorescent fixtures.	
5. Thermal comfort.	5. Regulate temperature at 68°F (heating), 78°F (cooling). Provide 10 cubic feet per minute per person outside air ventilation rate with on-off switching.	5. See also Vol 2, SB2, Communication Station Buildings--Mechanical.
6. Electrical power.	6. Install 120/208 electrical service. Provide 120-volt outlets--one receptacle for every 10 linear feet of wall. Frequency levels should be at 50 to 60 hertz ± 5 percent.	6. See also Vol 2, SB2, Communication Station Buildings--Electrical.
7. Fire protection/life safety criteria are based on the assumption that this facility is windowless and houses critical equipment and data that have a severe strategic fire loss potential.	7. Interior finish--Class A or B only. Corridor finish--Class A only. Automatic fire suppression--Water sprinklers. Automatic notification/alarm--General alarm activated by the automatic suppression system and transmitted to the annunciator panel and local fire department or constantly staffed station outside the facility.	7. See Standardized Modules--Building Design Principles, and Vol 2, SB3, Fire Protection/Life Safety, for more information.

guidance



guidance

ANTENNA FIELDS HF 13


TRANSMISSION
ANTENNA FIELDS
HF 13
Transmission HF4
Dummy Load Area HF11
Control Monitoring HF8
Patch & Test PT1
Screen Room HF7
Parts/ Main-tenance HF6
Security HF1
NCOIC Admin HF2
Personnel Support/ Training HF3
Ops Nco HF2
Storage HF12
Generator/ UPS HF9
Mechanical HF10
ANTENNA FIELDS
HF13
Systems TC2
Security HF1
Admin. HF2
Personnel Support/ Training HF3
Technical Control TC1
Receiving HF5
NCOIC Admin. TC2
Parts/ Maintenance HF6
Storage HF12
Screen Room HF7
Generator / UPS HF9
Mechanical HF10
RECEIVING

function

To receive and radiate radiofrequency (RF) energy while withstanding local environmental conditions.

policy/sop

1. Foundations for antenna supporting structures are designed and constructed in accordance with NAVFAC DM-2--Structural Engineering, and NAVDOCKS DM-7--Soil Mechanics, Foundations, and Earth Structures, and as defined by NAVFAC. (68) 7-1
2. Contractors usually do the concrete work for antenna structure foundations, which must conform with NAVFAC Specification 13Y--Concrete Construction, or with other standards designated by NAVFAC. (68) 7-2
3. Antennas shall have suitable direct-stroke lightning protection as well as a static-charge drain so that a lightning discharge will not pass through vulnerable system components. (68) 6-22
4. Both physical and electrical inspections and tests must be performed once the antenna is installed. Physical inspection of HF antenna systems should be completed before electrical tests begin. Inspections should be conducted using procedures that will detect installation deficiencies and provide reference data for future inspections and maintenance records. (68) 8-1 (See General Inspection Procedures, Chap 8)

   The test plan should be such that the same procedures used for post-installation checking can be used in future maintenance tests. (68) 8-5
5. After an HF antenna system has been placed in service, periodic tests and inspections should be conducted to determine the operating efficiency of all components in the system. Data recorded during the post-installation physical and electrical checks, used in conjunction with manufacturer's specifications, form the basis for preventive maintenance through comparison and are a valuable source of information during periods of corrective maintenance.

   The individual communications activity establishes a program for system tests. These tests usually are incorporated into the preventive maintenance program. (68) 8-14

issues and assumptions

1. Periodic inspection

Maintenance requirements and needs will vary with the type of antenna being serviced and with the climate and location of the antenna site. The one requirement common to all antenna maintenance, regardless of type and location, is inspection. Visual inspection of the antenna structure on a regular basis will prevent small problems from becoming large ones. Corrective action can then be taken before the structure fails. (46) 3-5

2. Maintenance of the antenna field

The condition of the area around and under an antenna, if not properly maintained, can adversely affect the antenna's electrical performance. Virtually all HF antennas depend somewhat on the ground surrounding them for proper performance. Some types of vertically polarized antennas, such as the conical monopole or the inverted cone, require a ground screen on the earth under them. This ground screen and immediate area is essential to proper antenna performance. (46) 3-6. Table HF-1 shows maximum allowable vegetation height for various classes of antennas.

3. Type of guy wires

In most areas, mylar or polyester rope guys are unsatisfactory. They tend to flake and are difficult to keep in tension. They should be replaced with fiberglass rods. (46) 3-14. Guys that appear slack should first be carefully inspected to determine the cause of loosening. The area around the anchors should be inspected for earth heaving. Anchors should be examined for rust. Fiberglass guys should be inspected at the point the rod enters the socket. Wire rope guys should be examined for broken strands or insulators. (46) 3-14

If only a tightening of the guy is required, use a tensiometer and take up on a turnbuckle. In some cases, it may be necessary to use three tensiometers and two transits to insure correct plumb and proper tension on all guys. (46) 3-14

4. Pressurizing transmission lines

Moisture accumulation in coaxial transmission lines must be prevented to avoid unnecessary power loss, impedance discontinuities, or eventual failure. Since it is virtually impossible to install and maintain a long length of transmission line that is completely free of leaks, the line eventually will accumulate moisture unless pressurized with dry air. (46) 4-A1-1

5. Associated antenna components

The performance of any antenna system depends not only on the antenna, but also on the components used with it. Transmission lines,

issues and assumptions

impedance matching devices, dissipation and terminating devices, multicouplers, and lightning protection devices must be designed and installed properly to achieve satisfactory antenna performance. (See reference NAVELEX0101, 104, Chapter 6 for further information.) (68) 6-1

6. Required land area

The antenna's size and the area needed to comply with antenna separation requirements must be considered in estimating the real estate necessary for installation. Real estate and antenna costs should not be overlooked; however, cost considerations should not take precedence over the requirements defined by the propagation analysis. (68) 5-4

TABLE HF-1. MAXIMUM ALLOWABLE VEGETATION HEIGHT FOR VARIOUS CLASSES OF ANTENNAS

Antenna Class	Max. Allowable Vegetation Height
Broadband Monopoles Types: AS-1973-1974-1975/FRC AS-2205/FRC AS-2212,2213,2214/FRC	6 inches over area extending 3 feet beyond ground screen
Fixed Vertical Log Periodic Antennas Types: Granger 1703-1, 1703-2, 1703-3, 1703-4	6 inches within antenna and guy-system area
Fixed Horizontal Log Periodic Antennas Types: Granger Series 1701 & 1702	12 inches within antenna and guy-system area
Rotatable Log Periodic Antennas Types: AS-1862/FRC, (LPH-9) AS-2187/FRC, Collins 237A	A maximum of 12 inches is recommended for accessibility and fire protection. However, vegetation height of several feet will not affect antenna performance.
Rhombic Antennas Types: Generally designed for specific application	A maximum of 12 inches is recommended for accessibility and fire protection. However, vegetation height of several feet will not affect antenna performance.

issues and assumptions

7. Antenna support foundations

Foundations and support structures should be provided for antenna erection. Details of fixed-site antenna support foundations are in the drawings provided by antenna support manufacturers. (87) II-10

Foundation requirements can be determined only after soil properties have been ascertained by field observation, boring, sampling, and analysis as specified in NAVDOCKS DM-7. The data thus obtained are considered in conjunction with the type of supporting structure and the stresses resulting from factors such as wind and ice loading, temperature changes, and other weather conditions that affect structural stability. (68) 7-2

8. Ground plane

A ground plane is required for any ground-mounted antenna if the antenna is fed in a way that makes the earth the return path for current flow. An arrangement of wires comprising a ground plane improves (1) antenna radiation efficiency and (2) the low-loss path for the return current. (68) 3-2

Conical monopoles, discones, inverted cones, sleeves, and some vertical log periodic antennas (LPAs) are typical antennas that require ground planes. (68) 3-2

Ground planes can be considered in three basic categories: radial grounds, ground mats, and counterpoises. (68) 3-2

9. Lightning protection

Since antennas usually are located at a height above other structures on a transmitter or receiver site, they are likely to be in the path of lightning discharges to earth. They should therefore have suitable direct-stroke lightning protection as well as a static-charge drain so that a lightning discharge will not pass through vulnerable system components. Protection systems should be able to prevent lightning strokes from breaking down dielectric materials in antennas and transmission lines, and to prevent damage to all other components in the transmitting and receiving systems. In any lightning protection system, a path to ground must be provided that will offer less resistance and inductance than any other alternative path. (68) 6-22

Grounded metal towers and support structures create a lightning protection effect called the "cone of protection." Since a direct lightning stroke tends to take the lowest resistance path to ground, these tall, grounded structures will draw lightning strokes and thus protect surrounding objects from a direct hit. This protection is usually effective for objects within a cone centered on the grounded structure and with a base radius of one to two times the tower height. Thus, metal towers can provide a degree of protection for the antennas they support as well as for transmission lines within the immediate area. (68) 6-22

issues and assumptions

10. Battery banks for backup power

The use of batteries for backup power is impractical at high-power, MF/HF-transmitting facilities. Some use can be made of batteries for backup at receiving facilities and possibly for low-power (up to 1-kilowatt) transmitter facilities, but even this is questionable. Normally there will be engine-driven generators at the facility to pick up the load within approximately 1 minute of the power failure. Maintaining large banks of batteries for occasional power outages may not be cost-effective. (87) II-86

11. Commercial power versus generators

Normally, an MF/HF-transmitting or -receiving site will operate from commercially supplied power using local generators for backup. In some areas of the world, however, commercial power may not be available. If it is, it may be so unreliable as to be unusable for the technical load (for example, area lighting and housing). In such cases, the primary power source should consist of generators located on the facility site. (87) II-83

12. Uninterruptible power supply (UPS)

In some cases, a UPS may be necessary to supply a critical technical load. The system used depends on the power requirements, line voltage, and frequency deviations the critical technical load can tolerate. In general, a UPS is not practical for a large transmitting facility; however, there may be cases when it is needed to insure continuity for some critical receiving circuits. In these cases, a small- or medium-size UPS might be used.

13. Tower installation

Towers usually are provided and installed by the antenna manufacturer or by a contractor experienced in structural rigging. Inexperienced personnel should not attempt the tasks of assembling, erecting, and guying steel towers.

To facilitate fast procurement of standard, commercially manufactured steel radio towers 300 feet tall or less, towers that meet the specification and design requirements of Electronic Industries Association (EIA) Standard RS-222 should be requested. NAVFAC must be consulted, on an individual project basis, for installation criteria on towers over 300 feet high. NAVFAC also should be consulted for adequate tower and foundation design criteria and for review of other tower heights and antenna types. Steel materials used in towers must conform to the requirements in NAVFAC DM-2 or as further defined by NAVFAC. (68) 7-3 (See Guidance for further information regarding free standing and guyed towers.)

Issues and assumptions

14. Terrain considerations for site selection

HF antennas should be located on reasonably flat ground. Areas with large concentrations of rock should be avoided because grading and construction problems are magnified by such terrain and because soil dissimilarities may cause nonuniform ground constants. (68) 3-6

Antennas should be sited so that obstructions such as buildings, tall metal structures, and mountains are not in the direction of propagation. The obstruction angle for a given wavepath must not exceed 5 degrees (3 degrees is preferred). (68) 3-6

15. RF radiation hazards

Careful attention must be given to site selection for transmitting antennas with regard to RF radiation hazards. (68) 3-6

a. Hazards of electromagnetic radiation to ordnandce (HERO)--Siting transmitting antennas in areas at which ordnance materials are located can create a potential hazard. Therefore, site approval with regard to ordnance materials is required in accordance with NAVFAC Instruction 8020.3--Site Approvals for Electromagnetic Wave Generating and Transmitting Equipment, 16 February 1968.

b. Hazards to fuel--The exposure of fuel to RF radiation is discussed in NAVORD 3656/NAVAIR 16-1-529--Technical Manual, Radio Frequency Hazards to Ordnance, Personnel and Fuel (U0, and in NAVELEX 0101,103).

c. Hazards to personnel--Safe exposure limits for protecting personnel against the effects of RF radiation are discussed briefly in Guidance--Radiation hazards.

16. Separation from sources of interference

Interference from sources of EM radiation, such as radio and radar transmitters, and noise from electrical devices are important in siting HF receiving antennas. To minimize the effects of this interference, receiving antennas should be sited in accordance with separation distances specified in Guidance--2, Receiver site. (68) 3-7

17. Antenna selection criteria

Table HF-2 summarizes several types of MF and HF antennas. Various applications and conditions of antenna usage are in the left-hand column. An "X" in the block identifying an antenna indicates the antenna(s) best suited for that particular application or condition. This evaluation is subjective and may not apply to every situation; it is intended only as a guide in the initial selection process. Detailed system engineering using suitable references should be done before final antenna selection. (87) II-52

Issues and assumptions

Some antennas available are (see Systems section):

1. Rotatable log periodic antennas
2. Inverted cone antennas
3. Conical monopole antennas
4. Fixed log-periodic antennas
5. Fixed horizontal log-periodic antennas
6. Rhombic antennas
7. Special rhombic configurations
8. Short range HTOA wide-band antennas
9. Hermes loop array
10. Half-wave antenna (dipole/doublet)
11. Yagi antenna
12. Sector log-periodic array
13. Whip antennas
14. Sleeve antennas
15. Discone antennas
16. Selectively directional monopole antenna
17. Horizontal vee antenna
18. Wullenweber antenna array
19. HF quadrant antenna

18. Noise level

The RF noise level is of primary significance for a receiver site and of less importance for a communications center or a transmitter site. (69) 4.2

TABLE HF-2. ANTENNA SELECTION CRITERIA. (87) II-53

Application/Conditions	Half-wave Dipole	Yagi	Terminated Vee	Rhombic	Horizontal LP	Vertical LP	Rotatable LP	Vertical Monopole
Long Range Point-to-Point				●				
Long Range Multipoint					●	●		
Medium Range Point-to-Point			●	●				
Medium Range Multipoint							●	●
Short Range Point-to-Point	●		●					
Short Range Multipoint		●					●	●
Transportable, Long Range			●				●	
Transportable, Short Range	●							
Broadcast						●		●
Limited Space	●	●						●
Low Frequency								●
Low Cost	●	●	●					

NOTE: The "X" indicates the antenna(s) best suited for the given application or condition.

requirements	criteria	commentary
1. Suitable site.	**1.** Site selection must be done to find a suitable site. This is the process of determining if a particular piece of land can be used satisfactorily as an MF/HF-transmitting or -receiving facility. The site selection process involves a long-range, tentative site area selection; tentative site selection using map studies; presurvey information gathered by teams visiting all candidate sites; and final site surveys in which teams visit one or more final site selections and gather detailed information on their adequacy. From this information, a decision is made as to the best site to use for the required MF/HF communications facility. (87) 4.2	
2. Specific design guidance for receiver site.	**2.** For reliable reception of weak signals from distant stations, the receiving antennas must be located in an electromagnetically quiet area, relatively isolated from manmade noise. Of the three major sources of RF noise--galactic, atmospheric, and manmade--the latter is of chief concern since it is the one over which some control can be exercised. (69) 4-2	
3. Specific design guidance for transmitter site.	**3.** The main concern in selecting a transmitter site is the potential for RF interference with other operations such as receiving stations and local commercial broadcast reception. This factor, coupled with the large area needed for the antenna park, may demand that the site be remote from populated and industrial areas. (69) 4-5	
4. Antenna spacing.	**4.** The area requirement for a receiver or transmitter site depends mainly on the number and type of antennas involved, because buildings usually occupy only a small section. Since mutual coupling depends on antenna azimuths and spacing, the required size and shape of a site cannot be standardized.	
5. Antenna separation.	**5.** Separation of HF antennas is an important factor affecting antenna performance. The criteria for separation are determined by the antennas' physical and electrical characteristics and by the intended use (transmitting or receiving). (68) 3-7	
6. Antenna poles for structural support of antennas.	**6.** Wooden poles used as HF antenna supports vary in size according to the antenna's characteristics; for example, antenna height above ground, and length, size, and weight of the antenna wire all affect pole size. The selection of wood poles for antenna supports is based on species, length and class of pole, and type of wood treatment. Poles are cut and prepared under American Standards Association (ASA) specifications and are treated in accordance with the American Wood Preserving Association Standards (AWPA). When special requirements are anticipated or when there is a conflict between specifications and requirements, NAVFAC must be consulted. (68) 7-14	

requirements	criteria	commentary
7. Pole and tower lighting/painting.	**7.** Poles and towers that are a potential hazard to aircraft must be marked at night with obstruction lights. A typical system consists of a double light fixture, a transfer relay, and a photoelectric control unit that automatically turns the light on at dusk and off at dawn. The double-fixture obstruction light is mounted directly onto the end of the power cable conduit and is located so that it extends above the pole or tower to be lighted. The transfer relay, mounted directly in the conduit run, automatically switches the power to the spare light should the operating light fail. The photoelectric control unit is mounted directly onto the pole with lag screws or is mounted with bolts to a cross-piece attached between the legs or braces of a tower. To warn airmen of the obstructions during daylight hours in good weather conditions, all structures that may present a hazard will be painted from top to bottom in accordance with requirements of the latest edition of FAA-AC 70/7460-1. (3) 5-40	
8. Vegetation and herbicides.	**8.** Antenna fields should be drained well enough that maintenance personnel have access to antenna support structures, guys, feeders, and dissipation lines. Antenna fields should be planted with a low ground cover to control erosion from wind and water. Vegetation should not be allowed to grow so much that site access is impaired or that the electrical "flatness" of the area under the antennas is affected. The type of cover will vary with the climate; therefore, local agronomists or university agriculture extension services should be consulted. (87) 4.3.3.8	
9. Concrete forming and testing.	**9.** The elevation of antenna foundations is particularly important in the construction and installation of HF antennas that have multiple supports separated by considerable distances. Tower and foundation specifications usually provide for a maximum tolerance of ±.5 inch if the foundation can be adjusted by grouting. (68) 7-2	
10. Assembly and erection of guyed towers.	**10.** Simple antennas intended for assembly in the field usually are built on the ground and then hoisted into position. In this case, good work practices and strict attention to the detailed assembly instructions are the main requirements. Some other antennas, such as rhombics and similar curtain-type antennas, are essentially constructed at the site. In wire antenna installation, the breaking load of the wire type being used has considerable effect on wire element measurements and installation. (68) 7-25	

requirements	criteria	commentary
	Sections for lightweight towers usually are preassembled before delivery to expedite final tower assembly; heavier weight towers must be completely assembled in the field. (68) 7-4	
11. Assembly and erection of freestanding towers.	**11.** Freestanding (self-supporting) steel antenna towers are characterized by heavier construction than guyed towers and by a shape that tapers in toward the top from a wide base. Freestanding towers exert much greater weight-bearing pressure on foundations than most guyed towers; deeper foundations thus are required (because of the greater size, weight, and spread of tower legs) to provide enough resistance to uplift. Each leg of a freestanding tower must be supported by an individual foundation.	
12. Central dry air system.	**12.** Moisture accumulation in coaxial transmission lines must be prevented to avoid unnecessary power loss, impedance discontinuities or, eventual line failure. Since it is virtually impossible to install and maintain a long length of transmission line that is completely free of leaks, the line will eventually accumulate moisture unless it is pressurized with dry air.	
13. RF radiation and shock hazards to personnel.	**13.** RF radiation and electrical shock from HF transmitting antennas are potential hazards to personnel. The basic standards for protecting personnel against radiation hazards are contained in NAVORD 3565/NAVAIR 16-1-529. This publication also contains HERO and fuel hazard information. Use of these standards in relation to HF antennas is discussed in section 8.4 of ref 68, p 8-14.	
14. Periodic maintenance of transmission lines.	**14.** Most transmitter sites use a 3-1/8-inch air dielectric heliax transmission line. When properly installed, it is airtight and moisture-proof and requires only that proper dry air pressure be maintained. (46) 3-2 A variety of pressurization systems are available. Some have several small compressors providing air for one, two, or three lines. Newer installations have a large central compressor that cycles automatically, feeding all transmission lines through a system of valves and gages. Gages usually are placed at the switching matrix where they can be checked daily by operating personnel. (46) 3-2	

requirements	criteria	commentary
15. Lightning protection.	**15.** Lightning protection for towers shall be in accordance with the latest edition of Underwriters Lab (UL) Pamphlet 96A, Lightning Protection Systems. (3) 5-39 o Provide inline gas discharge lightning protection units for both transmission and receiving lines along with a grounded panel at the entry point of all lines, including waveguides.	**15.** See also SB4 - Grounding, Bonding, and Shielding for more information.
16. Cable trenching.	**16.** Cable trenching should be provided for receiving antennas and for transmitting antennas fed by coaxial cable. The routing and details of the cable trench are on the site layout drawings for the particular equipment or facility that requires cabling. (87) 4.3.3.4	
17. Fire breaks.	**17.** Provide an interior strip or access roadbed. This must be kept clean out to mineral soil or surfaced road to stop the spread of fire and permit ready access to the area. (46) 3-11	
18. Fuel breaks.	**18.** Modify the native vegetation permanently on a relatively wide strip of land so the fires burning into it can be controlled readily. The vegetation allowed to grow within the fuel-break strip is generally a low growing groundcover to protect the soil against erosion, yet offer a light fuel volume so that if it burns, the heat output will be low. (46) 3-11	
19. Tower plumb.	**19.** Antenna towers should be plumbed in accordance with Section 5 of the American Institute of Steel Construction (AISC) Standard Practice (5-149): In the erection of structural steel for structures other than bridges and multi-story tier buildings, the individual pieces are considered plumb, level, and aligned if the error does not exceed 1.500 inches.	

guidance

1. Site selection

The primary consideration in site selection is technical adequacy. Factors such as construction difficulties; political, fiscal, and auxiliary support requirements; and other logistic problems must be considered in evaluating possible sites. However, technical suitability must always take priority. (87) 4.2.1.1

Designers must consider the following: (87) 4.2.1.2

- Location with respect to the radio horizon and the probability of maintaining desired transmission take-off angles.
- Location with respect to existing terminals when facilities are not collocated.
- Magnitude of construction required for site development, implementation, and facility maintenance.
- Practicality of initiating and maintaining an adequate logistic support program.
- Feasibility of land acquisition and possible political ramifications.

Detailed information on the site selection process is in MIL-HDBK-413.

A map study can help in the preliminary site investigation by relating the following information: (87) 4.2.1.3

- Preliminary determination of site terrain suitability.
- Area of land available at a proposed site location.
- Take-off angle clearances on projected azimuths.
- Location of possible sources of EM interference--high voltage transmission lines, power substations, power-generating plants, or existing military or commercial transmitters.
- Access to, and location of, the support base and transportation facilities.
- Potential physical restrictions to construction of station facilities and antenna structures.
- Approximate geographic coordinates of the proposed site.
- Potential political problems.

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The ground for a considerable distance in front of the antenna is important in forming the vertical radiation pattern. For example, when high angles of arrival and departure are used for short hops, the extent of clearance required in front of the antenna is not as great as for long radio paths for which low angles are used. For an ideal site, the area would be perfectly smooth and unobstructed with good ground conductivity. The reflection zone surface should have no abrupt changes greater than one-tenth of the antenna height and no slope greater than 10 percent in any direction. Good engineering practice is to limit surface irregularities in the entire active ground area to 0.1 wavelength at the highest operating frequency. Any major obstruction in the direction of propagation, such as hills, houses, or trees, should subtend a vertical angle less than one-half the angle between the horizontal and the lower 3-decibel point of the beam takeoff angle. (87) 4.2.1.4

2. Receiver site

Once established in a quiet area, a receiver site must be protected from encroachment to insure that it will remain quiet. When possible, this protection should be secured legally. Future construction that may adversely affect communications should be legally prohibited within a zone surrounding the site beyond the station-owned protective corridor. Registry of this encircling land area in accordance with local and state laws to restrict further development is the most desirable way to provide necessary site protection. Alternative methods of insuring protection are through zoning regulations that limit land development (again, registry in accordance with local and state laws is required), or by entering into land-use covenants with all owners of the restricted land area. However, these two alternative methods are generally less effective because of increased real estate costs, time consumed in negotiation, and possible future litigation. (69) 4-2

Receiver site isolation requirements--Table HF-3 gives criteria for separating a receiver site from other components of a communications station and from interference sources. These data, although validated by experience, usually are verified by signal and noise measurements at the sites being considered. (69) 4-2

Receiver site manmade noise and unwanted signal survey requirements--Field strength must be measured at receiver sites to evaluate the level and population of unwanted signals, to establish the ambient noise level, and to locate sources of RF interference. An initial survey with mobile equipment is strongly advised. Spot checks on main highways and country roads located within 10 miles of the site can identify noise sources and give an indication of the potential interference level. The value of this preliminary noise survey improves in proportion with the time spent in obtaining data at various times of day and at many locations. (69) 4-2

The final survey must be conducted from near the center of each receiver site being considered seriously. This survey should last long enough (usually several days) to gather statistically significant data for the site's manmade noise characteristics. Noise field-strength measurements must be recorded to determine the site's ambient noise

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level throughout the frequency spectrum of interest at various times of day. (69) 4-5

It is not always possible to separate individual noise sources from the composite noise level. One way to determine the level of a particular source is to measure it at the source and determine its effect at the receiving site by calculating attenuation as the inverse of the distance squared. A loop antenna to provide directivity will aid in determining the interference source's direction from the station. (69) 4-5

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SOURCES OF INTERFERENCE	MINIMUM DISTANCE
High-power transmitter stations:	
VLF	25 mi
LF/HF	15 mi
Other transmitters not under Navy control	5 mi (see note 1)
High-voltage power lines 100 kV or greater:	2 mi
Receiver station power feeders:	1000 ft from nearest antenna
Airfields and glide paths:	
For general communications	5 mi
For aeronautical receiving at air station	1500 ft
Teletype and other electromechanical systems:	
Low level operation or installed in shielded room	No minimum
High level operation installed in unshielded room	
Large installation (communications center)	2 mi from nearest antenna
Small installation (1 to 6 instruments)	200 ft from nearest antenna
Main highways:	1000 ft
Habitable areas (beyond limits of restriction) :	1 mi
Areas capable of industrialization (beyond limits of restriction - see note 2) :	
Light industry	3 mi
Heavy industry	5 mi
Radar installation:	(See note 3)
Primary power plants:	5 mi

Note 1: The following NAVELEX requirements also govern distances to non-Navy transmitter stations:
- (a) Signal from non-Navy station shall not exceed 10 millivolts per meter (field intensity) at Navy site boundary.
- (b) Harmonic or spurious radiation from the non-Navy station shall not exceed 5 microvolts per meter (field intensity) at the Navy site boundary.

Note 2: The restriction limit is the protective corridor; i.e., that area between the outer limits of antenna field and the site boundary.

Note 3: Calculate using "Electromagnetic Prediction Techniques for Naval Air Stations," White Electromagnetics, Inc., Rockville, Maryland, NObsr 87466.

TABLE HF-3. RECEIVER STATION SEPARATION DISTANCES

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3. Transmitter site

An extensive noise survey usually is not required. Siting transmitters in an area at which interference will not cause adverse effects is more important than choosing a site with a low ambient noise level. The criteria in Table HF-4 apply to separation of the transmitter site from other facilities. (69) 4-5

Transmitter Station Separation and Clearances

FACILITY	MINIMUM DISTANCE
Overhead high-tension power lines	1000 feet from nearest antenna
Main highways	1000 feet
Other transmitter stations	3 miles
Airfields and glide paths	3 miles when the station is used for general purpose communications — 1500 feet when the station is used in conjunction with air operations
Communications center	5 miles when VLF transmitters are installed
Receiver site	25 miles when VLF transmitters are installed — 15 miles when LF and HF transmitters are installed

TABLE HF-4. TRANSMITTER STATION SEPARATION AND CLEARANCES

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4. Antenna spacing

Table HF-5 can help determine required spacing between antennas when laying out an antenna farm. (87) 4.4.5.6

TABLE HF-5. TYPICAL ANTENNA SPACING DISTANCES.

Rhombic antenna	300-meter (1000-foot) clearance in the direction of transmission; 75-meter (250-foot) clearance at sides.
Log-periodic antenna, horizontal polarization	Same requirements as the rhombic antenna.
Log-periodic antenna, vertical polarization	300-meter (1000-foot) clearance in the direction of transmission, same clearance as for the monopole in all other directions.
Broadband vertical antenna (monopole)	At least one wavelength at lowest operating frequency in all directions.
Dipole antenna	One wavelength clearance in direction of maximum transmission. Dipoles can be placed end-to-end using a common supporting mast, provided they are generally oriented along the same path bearing.

When transmitting antennas must be oriented with paths crossing, their separation should be such that the convergence point of radiation paths is more than 1000 feet in front of either antenna. (87) 4.4.5.6.1

Receiving antennas operating in space diversity on the same circuit should be separated from each other by 1000 feet in all directions. If possible, diversity antenna lateral separation should be five wavelengths when installed in line on the path bearing. The best arrangement is to locate the antennas for both lateral and forward separation. (87) 4.4.5.6.2 The following general considerations apply when locating HF antennas: (68) 3-6

- Fixed directional antennas, such as rhombics and LPAs (horizontal and vertical), should be sited so that the main beam does not radiate through other HF antenna arrays. This requires that they be located at the antenna park perimeter nearest the azimuth of the intended direction of transmission or reception.

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- Rotatable log-period antennas (RLPAs) should be grouped together when possible to reduce any detrimental effect their supporting towers may have on vertically polarized antennas.

- High frequency antennas, such as RLPAs and some conical monopoles, should be located as close as possible to the transmitter or receiver building to minimize coaxial line losses.

- HF antennas for which spacing requirements are the same should be grouped together to conserve real estate.

- When land availability is critical, it is possible to locate a vertically polarized antenna within the area occupied by a rhombic antenna without sacrificing performance. In these installations, the vertically polarized antenna should be located near the center of the rhombic clear of the rhombic curtains, feed pole, and terminating resistance. The rhombic array in which the other antenna is located should have wood supporting structures, and the guy wires should be broken up with insulators. Also the rhombic should have a lumped termination resistance instead of dissipation lines to provide enough space for installing the vertical antenna.

- When a rooftop antenna is required, its location should coordinate with roof access openings where possible. Access to the roof should be from inside the building (possibly through operations or a hallway).

5. Antenna separation (Figure HF-4)

Separation requirements for antennas of unlike function--HF antennas of unlike function (transmitting and receiving) should be separated by a minimum distance of 15 miles. If this separation is decreased, the receive function may degrade seriously because of interference created by the transmitters. This interference can be caused by adjacent-channel operation, harmonics, keying transients, and parasitic oscillations. Also, cross-modulation products can be generated in HF preamplifiers and receivers by strong RF fields, even though normal receiving frequencies are widely separated from the frequencies of such fields. (68) 3-7

Separation requirements for antennas of like function--The separation distance between any two antennas of like function (all receiving or all transmitting) can be determined from the spacing criteria described below. Unless otherwise noted, all distances are based on the antennas' lowest design frequency. The greater of the two distances in each case is used as the spacing distance. The points of measurement are between the reference points listed for each type of antenna (except rhombics). (68) 3-7

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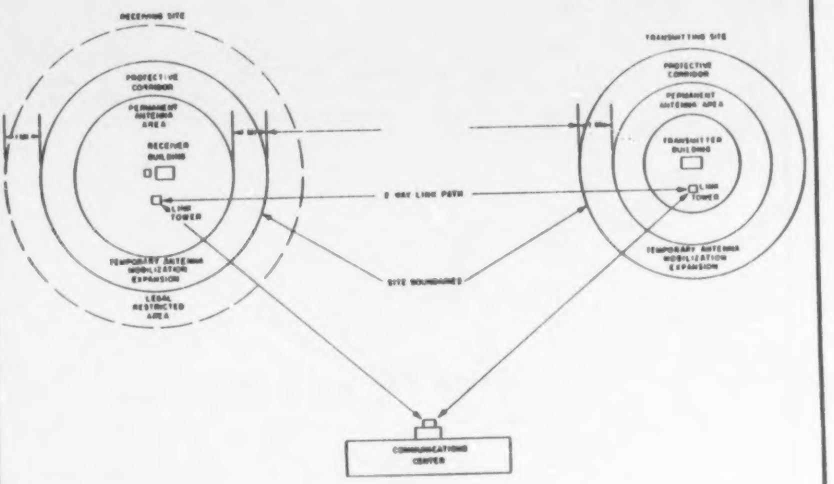


FIGURE HF-4. ANTENNA SEPARATIONS.

Rhombics. Rhombics should be separated 250 feet from other types of horizontally polarized antennas. The 250-foot distance is measured from the nearest radiating element of the rhombic antenna to the reference point listed for the other antenna. However, rhombics may be located immediately adjacent to other rhombics (including the sharing of common side and/or rear poles) as long as their radiators do not overlap.

Nesting a higher frequency rhombic inside its lower frequency complement (using a common rear pole) is permissible, and even encouraged, to reduce land requirements.

Vertically polarized antennas may be placed inside a rhombic.

Vee antennas. Spacing requirements are the same as for rhombics.

Horizontal LPA. Space two wavelengths from the main lobe and one wavelength outside the main lobe, measured from the main supporting structure (midway between supporting structures for two-tower configurations).

guidance

Vertical LPA. Spacing requirements are the same as for horizontal LPAs.

Rotatable LPA. Space two wavelengths from horizontally polarized antennas. The required separation from a vertically polarized antenna is determined by the spacing requirement for the vertical antenna. In all cases, spacing must be no less than 150 feet.

Yagi. Space one-half wavelength measured from the center of the nearest radiating element.

Horizontal doublet. Space one-half wavelength measured from the feed point.

Medium-frequency/low-frequency long wire. Space 500 feet measured from the feed point.

Inverted cone. Space one wavelength measured from the antenna center.

Conical monopole. Spacing requirements are the same as for inverted cones.

Sleeve. Space one wavelength measured from the sleeve element.

HF vertical radiators. These include vertical doublets and other discrete frequency antennas with a bandwidth of 10 percent or less at the center design frequency. Space one-half wavelength measured from the supporting structure.

Vertical low frequency tower. Space 1000 feet from all HF antennas.

Sector log periodic. Space two wavelengths measured from the main supporting structure.

Sector sleeves (90 and 180 degrees). Space two wavelengths measured from the sleeve element.

Selectively directional monopole. Space two wavelengths measured from each monopole element.

When transmitting antennas must be oriented with paths crossing, their separation should be such that the convergence point of radiation paths is more than 1000 feet in front of either antenna. (87) II-58

Receiving antennas operating in space diversity on the same circuit should be separated from each other by 1000 feet in all directions. When possible, diversity antenna lateral separation should be five wavelengths when installed in line on the path bearing. The best arrangement is to locate the antennas for both lateral and forward separation. TM 11-486-6 shows representative antenna farm arrangements. (87) II-58

guidance

In general, the RF noise level ranks low among other factors influencing or dictating the location of a communications center. Operational and administrative considerations are often decisive, as long as other less-than-ideal conditions can be either tolerated or improved. (69) 4-5

As with the transmitter site, a noise survey usually is not required, but care should be taken to separate the communications center from large generators, power transformer stations, heavy industrial equipment, high-powered HF transmitters, and other obvious sources of interference. A major objective is to prevent high-level noise or signals from interfering with d.c. signaling in the communications center. The established separation criteria are given in Table HF-6. (69) 4-5

Many communications centers are located on naval stations near the commands being served. However, nearness to the subscribers is only one factor to consider, not a controlling consideration. The site must be selected on the basis of overall operating efficiency consistent with economy and technical requirements. For example, a site chosen for direct line of sight between the communications center and the transmitter and receiver sites will reduce the difficulty and expense of establishing microwave links between the sites. This advantage may outweigh other factors such as nearness to a major command. (69) 4-5

TABLE HF-6. COMMUNICATIONS CENTER SEPARATION AND CLEARANCES

Source of Interference	Minimum Distance
VLF transmitters	5 miles
Radar installation	1500 feet

guidance

6. Wood antenna poles

All wooden poles used as antenna supports must meet the following requirements:

Standard poles--Poles must be either Douglas Fir or Southern Pine and are to conform to ASA Specification 0.51.

Roof--Poles must be cut at the top to form a one-way roof with a 15 degree slope.

Steps--Standard hook pole steps, 5/8 inch in diameter and 10 inches long are required. Hook steps should be installed with the first step approximately 3 feet above ground; all others should be 18 inches above each other. The steps are placed alternately on opposite sides of the pole.

Preservative treatment--Poles must be treated to prevent decay and insect damage. Treatment consists of the Full Cell Pressure Process in accordance with AWPA Standards C1 and C4, using as preservative a solution of creosote and coal tar. Creosote must meet the requirements of AWPA Standard P13; the creosote-coal tar solution must meet the requirements of AWPA Standard P12.

Final retention--Final retention of the preservative must be at least 16 pounds per cubic foot for Douglas Fir and 20 pounds per cubic foot for Southern Pine.

Wooden poles should be visually examined semiannually for splits, dry rot, decay at the base, and termites. Pole caps should be inspected to insure they are secure. (46) 3-11

If poles are set in metal sockets, pentachlorophenol should be applied annually to that part of the base in the socket to prevent decay. Mounting the poles on concrete pads is the most effective way to prevent decay. (46) 3-11

Every 2 years a core sampling should be taken from a random selection of poles to check for pole rot and termites. A hole should be bored into the center of the pole 3 to 4 feet above the ground line. If this reveals a hollow heart or insect galleries, one to three pints of B wood preservative (pentachlorophenol in a petroleum solvent) should be pumped into the hole using the nozzle of a sprayer or stirrup pump. Bore holes and spike holes should be plugged with treated or heartwood locust plugs. (46) 3-11

7. Pole and tower lighting

The number of lights required for a tower depends on the tower height. Table HF-7 and Figure HF-5 show FAA- and FCC-approved lighting systems for various tower heights. (68) 7-27

guidance

Higher towers require lights with greater brilliance and either a rotating red beacon or a beacon flasher to make the lights go on and off. (68) 7-27

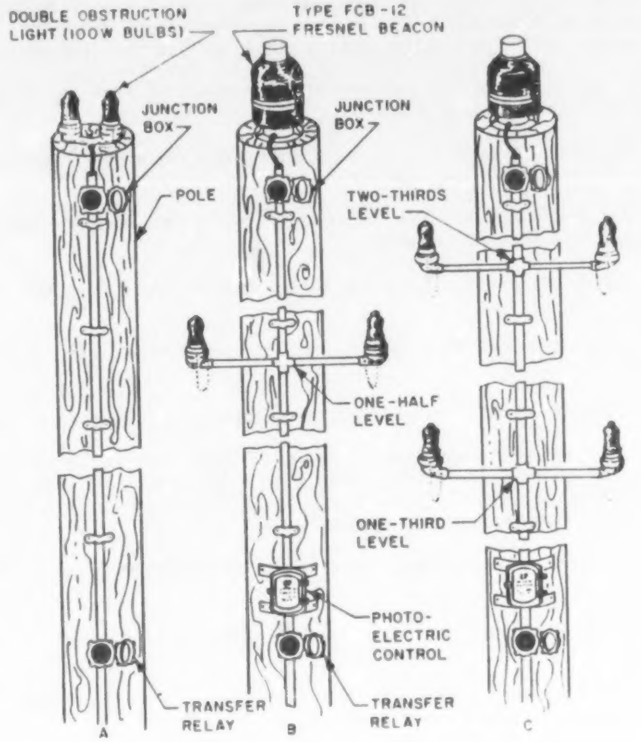


FIGURE HF-5. TYPICAL FAA- AND FCC-APPROVED OBSTRUCTION LIGHTS.

TABLE HF-7. FAA- AND FCC-APPROVED OBSTRUCTION LIGHTING SYSTEMS.

Tower Height (Feet)	FAA-Approved System Nomenclature	FCC-Approved System Nomenclature	Typical System Detail (Figure HF-5)
21-150	A-1	17.24	A
151-300	A-2	17.25	B
301-450	A-3	17.26	C

guidance

For certain areas, it has been determined that poles treated with ammoniacal copper arsenite are more resistant to rot and termites than poles treated with creosote (this is true, for example, in Guam). This should be considered when procuring wooden poles. (46) 3-14

Normally, pole steps, not climbers (spikes), should be used on wooden poles. However, depending on the age of the pole and climatic conditions, it may be safer to use climbers than to rely on the steps. (46) 3-14

Care should be taken in retensioning wooden poles. It is possible to overtension after they are set, causing them to twist. A slack guy may not necessarily need tightening; check the plumb first. (46) 3-14

The tower painting and lighting guidelines in this section apply primarily to installations within the United States. At overseas installations, regulations imposed by cognizant military and/or government agencies must be studied. To prevent hazards to air commerce, antenna towers and similar structures must be marked in a way that makes them conspicuous when viewed from aircraft. The type of marking to be used depends partly on the structure's height, location with respect to other nearby objects, and nearness to aircraft traffic routes close to landing areas. Requirements and specifications for marking and lighting potential hazards to air navigation have been established through joint cooperation of the FAA, FCC, DOD, and appropriate branches of the broadcasting and aviation industries. The specifications determined by these groups offset the final decision on whether a structure constitutes an obstruction to air navigation. When conducting the preliminary site survey, it is advisable to determine the prevailing ordinances concerning such structures, and perhaps to discuss them with local government and building authorities. When dealing with locations within CONUS, the latest copies of Government Rules and Regulations, FCC Form 715, FCC Rule, Part 17, and FAA Standards for Marking and Lighting Obstructions to Air Navigation (with all revisions) should be consulted. These rules apply to specifications for antenna structures and also describe the forms that must be submitted to FCC, FAA, and the U.S. Coast and Geodetic Survey (FCC Form 401A Revised, FAA Form 117, FAA Form ACA-114, and C&Gs Form 844). (3) 5-40

Both FCC and FAA lighting specifications are given in terms of antenna structure height. The requirements for towers and obstructions will be determined from FAA Specifications in the latest edition of AC 70/74690-1. The specifications further stipulate that placement of the lights on either square or rectangular towers shall be such that at least one top or side light is visible from any angle of approach. When a flashing beam is required, it shall be equipped with a flashing mechanism able to produce no more than 40 nor less than 12 flashes per minute with a period of darkness equal to one-half the luminous period. (3) 5-40

guidance

While the tower structure is under construction, FCC and FAA require that temporary lights, consisting of at least two 100-watt lamps enclosed in aviation red globes, be displayed at the top of the structure from sunset to sunrise. Lights must also be installed at intermediate heights if so stated in IAW FAA requirements. (3) 5-40

FCC requires towers to be lighted during sunset to sunrise unless otherwise specified. At unattended microwave installations, a dependable automatic obstruction-lighting control device must be provided. Light-sensitive controls will be used when manual control is not possible. This requirement will be met in microwave installations by using a tower lighting kit. These kits power the lights when the north skylight intensity is less than approximately 35 footcandles and they disconnect the power when the north skylight intensity is greater than approximately 58 footcandles. (3) 5-40

To insure the proper operation of tower lights, FCC specifies they must be inspected at least once every 24 hours; the inspection can be performed either by direct observation or checking a properly maintained automatic indicator designed to register the lights' failure. When obstruction lighting is not readily accessible for periodic inspection, the rules permit use of electric signaling devices to indicate lamp failure. Should the fault alarm system register a failure in obstruction or beacon lighting, the failure must be reported to the nearest FAA Airways Communication Station. FAA must be notified of any code beacon, rotating beacon, or top light failure if not corrected within 30 minutes after failure. (3) 5-40

8. Vegetation and herbicides

Table HF-8 lists acceptable herbicides of low and moderate toxicity with designations accepted by the Weed Society of America, American National Standards Institute (ANSI), and Federal Committee on Pest Control. Chemical names are those used by the American Chemical Society (ACS). Trade names by principal use or action of the herbicide, such as contact, growth regulator, soil, soil sterilant, or preemergence, are also provided. (46) 3-9

guidance

Herbicides of Low and Moderate Toxicity

Designation	Chemical	Principal Use*	Oral Toxicity Rating	Dermal Toxicity Rating	Commercial Formulation
Benefin	N-butyl-N-ethyl-tri-fluoro-2, 6-dinitro-p-toluidine	P	Low	Low	Emulsifiable concentrate
Bromacil	5-bromo-3-sec-butyl-6-methyluracil	SS	Low	Mod	Wettable powder
Chlorate-Chloride	Sodium chlorate and calcium chloride	SS	Low	Low	
Chloropropham	Isopropyl m-chlorocarbanilate	P	Low		Emulsifiable concentrate granular base
Dalapon	2, 2-dichloropropionic acid	GR, S	Low	Low	Water-soluble salt
DCPA	Dimethyl tetrachloro-terephthalate	P	Mod	None	Wettable power
Diuron	3-(3, 4-dichlorophenyl) -1, 1-dementhylurea	SS; P	Mod / Low	Low	Granular base Water-miscible liquid, Wettable power
DMSA	Disodium methanearsmate	C	Mod.	None	Granular base Wettable powder Water soluble
Fenuron	1, 1-dimethyl-3 phenylurea	SS	Low	Low	Granular base Wettable powder
MSMA	Monosodium methanearsonate	C	Mod		Emulsifiable concentrate – Water soluble salt
Naptolam	N-a-naphthylphthalamic	P	Low	Low	Emulsifiable concentrate – Granular base – Wettable powder
Prometone	2, 4-bis (isopropyla-minol-6-methoxy-s triazine	S	Mod	Low	Emulsifiable concentrate
Sodium chlorate	Sodium chlorate	SS, C	Mod	Low	Water soluble powder – Water soluble solid

*NOTE: C, Contact, GR, growth regulator, P preemergence, S soil, SS, soil sterilant

TABLE HF-8. HERBICIDES OF LOW AND MODERATE TOXICITY

9. Concrete forming/concrete tests

The following general procedures should be followed to insure correct forming of concrete structure foundations and anchors. (68) 7-2

Tie wires--When reinforcing steel is to be placed in the forms, use tie wires to hold the reinforcements and forms in position.

Anchor positioning--Position the forms and pour concrete anchors so that the front face of the anchor will be poured against undisturbed earth if possible. Anchor shafts are to be positioned directly in line with the tower at the specified design angle.

guidance

Attachment points--Eyebolts or similar hardware for rigging, tower erection, and maintenance should be placed in the concrete form by setting them in a template that will insure correct position and alignment.

Placing concrete--Place the concrete as near as possible to its final position. It should be distributed in layers and worked into place by spading or vibrating to eliminate voids and stone pockets. Insure that all reinforcing steel is embedded well into the concrete, and bring only enough fine mix to the surface to produce the finish desired.

Filling voids--After the forms have been stripped from the formed concrete, fill all voids and tie wire break pockets with cement mortar.

Backfill--Backfill materials are selected and placed in accordance with NAVFAC specifications. Place backfill around completed foundations and anchors in well tamped layers. Avoid using rocks, muck, sod, and lightweight materials. After backfilling, grade the area to prevent erosion and to eliminate water collection spots.

If the local cement, aggregate, or concrete is of unknown quality, sample test-cylinders of the mix are required before construction can begin. In most cases, field testing of the concrete mix is impractical, and laboratory services will be needed. When concrete tests are necessary, they should be conducted in accordance with American Society for Testing Materials (ASTM) Specifications C31 and C39, or with other NAVFAC specifications. (68) 7-2

When construction begins, slump tests (the ratio of water to cement) of the concrete are required to insure correct consistency of the mix as it is being placed. If the correct amount of water is added, the slump increases and the mix pours more easily; however, the concrete's ultimate strength is decreased if more than the correct proportion is used. Frequent slump measurements aid in achieving a consistent quality of concrete and provide a way to eliminate inferior quality mixes. Many companies that supply premixed concrete use a form of quality certification intended to serve as a guarantee of each delivery. The acceptability of such certifications should be checked with the nearest NAVFAC field activity or with a local government office. Acceptable certification can eliminate or reduce the need for on-site testing, which expedites construction progress. (68) 7-2

10. Assembly and erection of towers

Base supports for guyed towers vary according to the type of tower to be installed. Three common base types are the tapered tower base, the pivoted tower base, and the composite base (Figure HF-13 in paragraph 11). A tapered tower base concentrates the load from multiple tower legs onto a small area of the foundation. The pivoted base is used primarily on lightweight structures for ease of tower erection. A composite base is generally used with heavier towers since it offers much more supporting strength than the other two types. (68) 7-3

guidance

The following general procedures should be observed for the assembly and erection of towers:

Ground assembly--Assemble the tower sections on well leveled supports to avoid building in twists or other deviations. Any deviation in one section will be magnified by the number of sections in the complete assembly.

General preservation--Check all surface areas for proper preservation. Cover all holes and dents in galvanized materials with zinc chromate or other acceptable preservatives to prevent deterioration.

Bolts and hardware--If bolts or other hardware must be provided from on-site material, insure that they meet the specifications of NAVFAC DM-2.

Tightening bolts--When high-strength bolts are used in tower assembly, place a hardened steel washer under the nut or bolt head, whichever is to be turned. Care must be taken not to exceed the bolt's maximum torque limit. (68) 7-7

Wire suspended between supports must be long enough to allow for the sag that corresponds to the correct tension for the wire. Under static conditions, tension on antenna wires is adjusted to approximately 10 percent of their breaking strength without considering wind or ice load. This allows for a fairly generous sag, which can compensate for a considerable change in temperature, without increasing the tension to a danger point for very cold periods. (68) 7-25

Guywires and insulators

Guys and insulators can affect operating efficiency for any HF antenna system. The type of guys used (metal wire or nonconducting materials), placement relative to radiation fields, and positioning of insulators on metal guys must be considered to achieve desired antenna efficiency. Most HF antenna poles and metal towers are supported by several guys attached to different points on the structure and anchored in the ground. Guys made of metal wire may be resonant at some operating frequencies and, therefore, may act as reradiating or parasitic antennas. Detrimental effects of guywires usually can be prevented by observing the following precautions: (68) 6-26

Guywire location--Place guywires in a spot at which the radiation field from the antenna is weakest.

Break-up insulators--Place break-up insulators at random intervals on the guywire to interrupt the resonant lengths. This is particularly important if the guys cannot be located in a weak radiation field. The longest uninterrupted length should not exceed 0.1 wavelength at the antenna's highest design frequency.

guidance

Nonconducting guys--For some antenna installations, the use or break-up insulators to prevent resonance of metal guys may be expensive and impractical. If a large number of break-up insulators is required, consider using guys made from nonconducting materials. Although the cost of these guys is normally more than for stranded steel wire of comparable strength, the overall cost, with the high tensile strength insulators eliminated, could favor nonconducting materials. Mylar and fiberglass are suitable nonconducting materials for guywires. Manila rope may also be used, but only for temporary guying arrangements.

Tower guying

Steel towers and wooden antenna poles are guyed in two phases: temporary guying during tower or pole erection, and permanent guying in conjunction with plumbing the structure. (68) 7-18

Wooden poles erected and set to their specified depth are reasonably self-supporting under normal wind conditions. However, high winds can move a pole from its vertical position. Therefore, wooden antenna poles must be temporarily guyed during construction and installation, and then must be guyed permanently. (68) 7-18

Temporary guying of steel towers is always necessary when more than one tower section is erected. Under no circumstances should the tower be advanced more than two sections without guying. Permanent guys are to be installed before the temporary ones are removed. (68) 7-18

Guy anchors--Guy anchors are selected by the antenna manufacturer or installing contractor in accordance with NAVDOCKS DM-7 and other NAVFAC specifications. The antenna design and installation plans specify the anchor type, location, and hole depth required. (68) 7-19

Anchor shafts or rods must project far enough above grade to keep all connecting guywire attachments free of vegetation and standing water. Shafts and connecting attachments should be cleaned thoroughly and then coated with a petroleum preservative to slow weathering effects.

Soil conditions, anticipated wind and ice loading of the antenna, and the stresses placed on the guys by the wind loading and weight of the structure are determining factors in the choice of guy anchors. The following types of anchors are representative of those commonly used in antenna installations.

Temporary guying. Several materials, including stranded wire, wire rope, and fiber rope are acceptable for temporary guying. However, new manila rope is the most suitable because of its strength and ease of handling. The size of guy material required is determined by the height and weight of the structure to be guyed and by weather conditions at the installation site.

guidance

Secure the temporary guys to the permanent guy anchors, to temporary-type anchors, or to any nearby structure that provides the required supporting strength. Leave temporary guys in place until the structure is permanently guyed and plumbed. (68) 7-20

Permanent guying. Antenna structures are permanently guyed with steel cables or fiberglass sections to prepositioned anchors in conformance with the installation plan. Figure HF-6 shows two methods of guying triangular steel towers. Guys A, B, and C are secured to a single anchor; guys D, E, and F are secured to individual anchors. Both arrangements are satisfactory; however, the anchor that terminates guys A, B, and C must be able to withstand much greater stress than the individual guy anchor arrangement. Triangular tower guys are arranged so that three guys are spaced 120 degrees apart at each level of guying as shown in Figure HF-6. Square towers require four guys spaced 90 degrees apart at each guying level. The following general elevation requirements apply to guy attachments for towers.

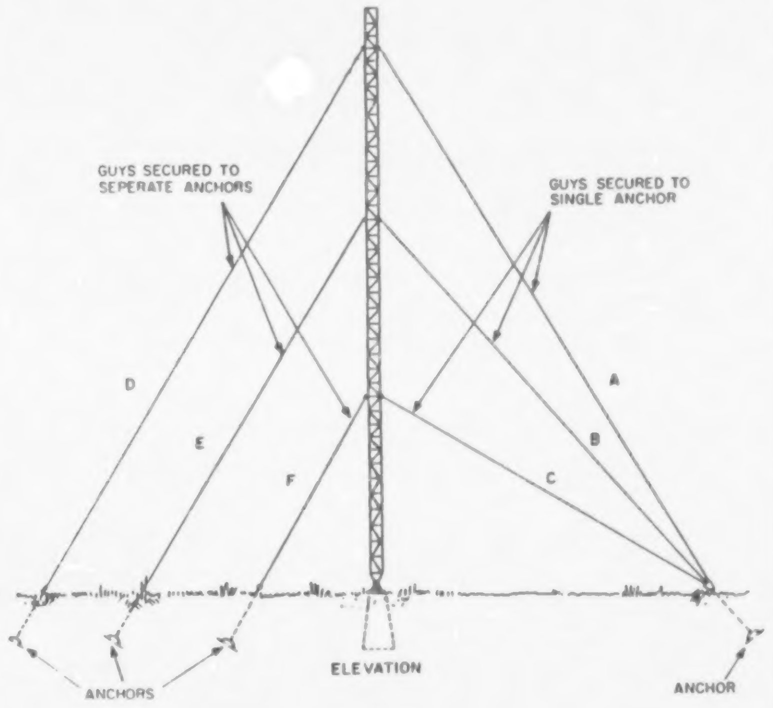

GUYS SECURED TO SEPERATE ANCHORS
GUYS SECURED TO SINGLE ANCHOR
D
E
F
A
B
C
ELEVATION
ANCHORS
ANCHOR

FIGURE HF-6. TOWER GUYING ARRANGEMENTS.

guidance

- Single-guy layer: The cable attachments are placed in at approximately two-thirds the tower height.
- Two-guy layers: Cable attachments are placed in positions at approximately 30 and 80 percent of the tower height.
- Three-guy layers: Cable attachments are placed in positions at approximately 25, 55, and 85 percent of the tower height.

Wooden poles set to the required depth in firm soil are permanently guyed primarily to counteract stresses (as opposed to towers, for which guys are used to provide vertical support). Locate wooden pole guys 120 degrees apart at each level of guying as specified in the installation plan and as determined by pole height and anticipated stresses. Position guys on the pole so that a 45-degree angle is formed from the pole attachment point to the anchor.

Tower guy tension--Setting guy tension and plumbing a tower are done at the same time and only when winds are light. Tension adjustment and tower plumbing are done as follows: (68) 7-22

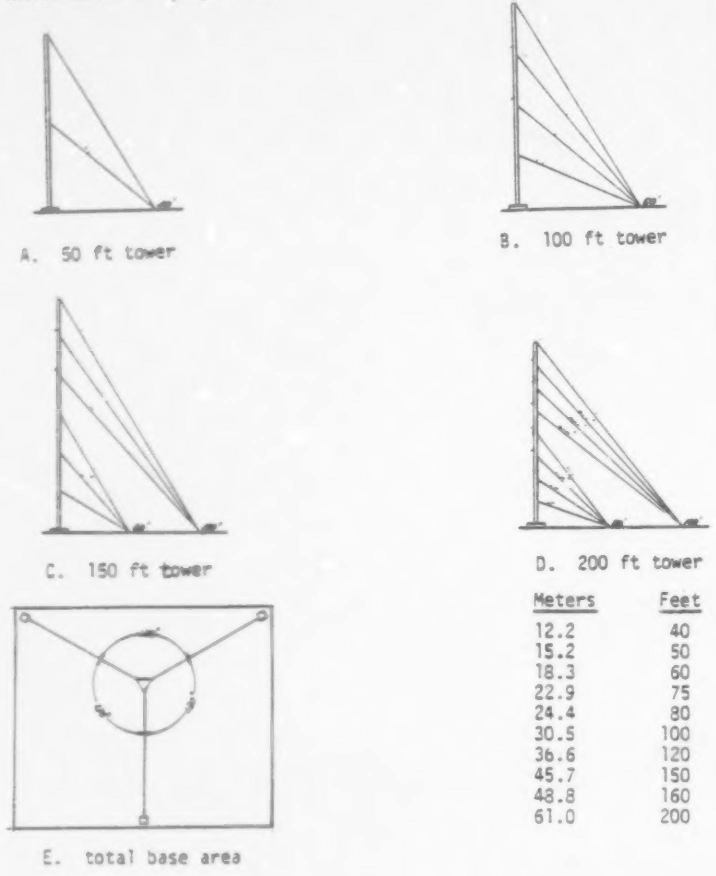
- Initial tension: All guys should be adjusted gradually to the approximate tensions specified in the antenna installation details. If tensions are not specified, guy tension should be adjusted to 10 percent of the guystrand breaking strength. (If fiberglass guys are installed, tensions must be set strictly in accordance with the manufacturer's specifications.) The tension on all guys is adjusted while insuring that the tower is in a stable, vertical position.
- Final guy tension: One procedure for final tensioning of tower guys measures final tension with a dynamometer. Carpenter stoppers or cable grips of the proper size designed for the lay of the wire must be selected for the tensioning operation. Any cable grip assembly that grips the wire by biting into the cable with gripping teeth could penetrate and damage the protective coating of guy cables and should not be used.

On some installations, other procedures for tensioning guys may be necessary because of the type of guys and hardware supplied with the antenna. For example, preformed wire helical guy grips are sometimes used for attaching guywires to the adjusting turnbuckles. In these cases, the techniques used for guy assembly, connection of guywire to the anchor, and tension adjustments must be determined from the detailed installation plan or the proper antenna technical manual.

guidance

Guys should be checked at least once per year to insure structural stability; they should be retensioned when the guy cable tension is found to be outside the limits specified in the proper technical manual or installation drawings.

Area requirements for guyed antenna support towers must accommodate space for the guys. Figure HF-7 shows typical guy dimensions. The towers shown require three sets of guys, although other manufacturers may specify four sets. Dimensions shown are typical and are provided for planning only. Manufacturers' dimensions should be used in all actual construction. (87) II-60



A. 50 ft tower

B. 100 ft tower

C. 150 ft tower

D. 200 ft tower

E. total base area

Meters	Feet
12.2	40
15.2	50
18.3	60
22.9	75
24.4	80
30.5	100
36.6	120
45.7	150
48.8	160
61.0	200

FIGURE HF-7. TYPICAL GUY DIMENSIONS. (87) II-61

guidance

Erection of guyed towers

Davit method--Lightweight guyed towers often are erected with a davit hoist which is anchored to the previously erected section; this provides a pivoted hoisting arm. The davit arm is swung away from the tower in hoisting the added section, and is swung centrally over the tower in depositing the section before bolting up the splice plates. Figure HF-8 shows a ground-assembled unit being hoisted for connection to a previously erected tower section. A snatch block secured to the tower base transmits the hoisting line to a power source or hand winch. A tag line secured to the base of the section being hoisted prevents possible contact with the erected portion of the tower. (68) 7-7

Gin pole method--Light, triangular guyed towers furnished with a pivoted base can be assembled completely on the ground and then raised to a vertical position using a gin pole. Figure HF-9 shows the lower section of a tower that has an attached pivoted base in a horizontal position prepared to hoist. The thrust sling shown counteracts the thrust on the base foundation from hoisting. Figures HF-10 and HF-11 show rigging operations and location of personnel essential to the raising of a pivoted base tower. Light towers approximately 80 feet long can be raised with a single attachment of the winch line. However, longer towers frequently are too flexible for a single attachment, and, in this case, a hoisting sling furnished with a snatch block allows for two points of attachment. The gin pole is mounted close to a concrete tower base and is provided with a top sheave to take the winch line. Personnel handle the permanent guys attached to the tower at three elevations during hoisting as shown in Figure HF-10. Temporary rope guys provided with snatch blocks anchored appropriately furnish the necessary lateral stability. As the mast approaches a vertical position, the permanent guys are fastened to the guy anchors installed before erection. (68) 7-8

Auxiliary mast method--Guyed towers of heavier construction require erection equipment of greater rigidity than the light davit previously described. Figure HF-12 shows a mast or gin pole furnished with a swiveled "T" head. At the top of the mast and at right angles to it is a revolving pin-supported head with the hoist line running over two separated sheaves. Tower sections are completely bolted on the ground, hoisted by the rig to the right elevation, kept away from the completed structure using a tag line, and then swung into place. After each new section is bolted securely, the mast is relocated and the process is repeated until the full height is reached. (68) 7-8

Hand assembly--Erection without a davit or gin pole is done by assembling individual members piece by piece as the tower is erected. The assembler climbs inside the tower and works with the lower half of his or her body inside the previously assembled construction. This person then builds the web of the tower section around him- or herself while progressing upward. As each member is bolted into place, the assembler should tighten all connections immediately so that at no time is he or she standing on or being supported by any loose member. (68) 7-9

guidance

Temporary guying often is required in the erection of guyed towers. Such guying is often necessary when several sections are erected before the elevation of the permanent guy level is reached. Requirements for temporary and permanent guying are in Guidance, "Guying." (68) 7-9

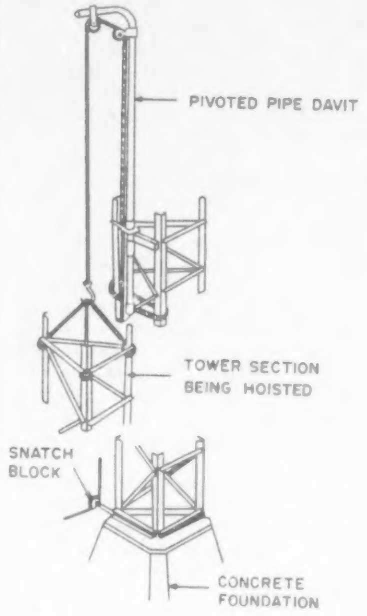

PIVOTED PIPE DAVIT
TOWER SECTION BEING HOISTED
SNATCH BLOCK
CONCRETE FOUNDATION

FIGURE HF-8.

TYPICAL DAVIT INSTALLATION.

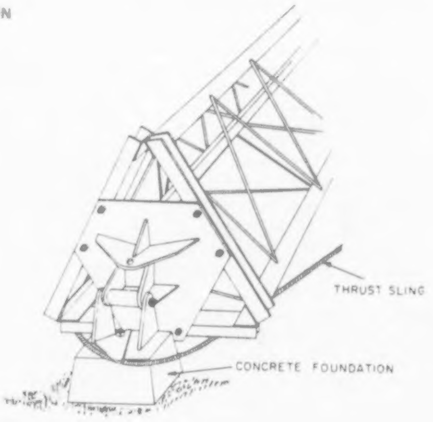

THRUST SLING
CONCRETE FOUNDATION

FIGURE HF-9. PIVOTED TOWER HOISTING PREPARATION.

guidance

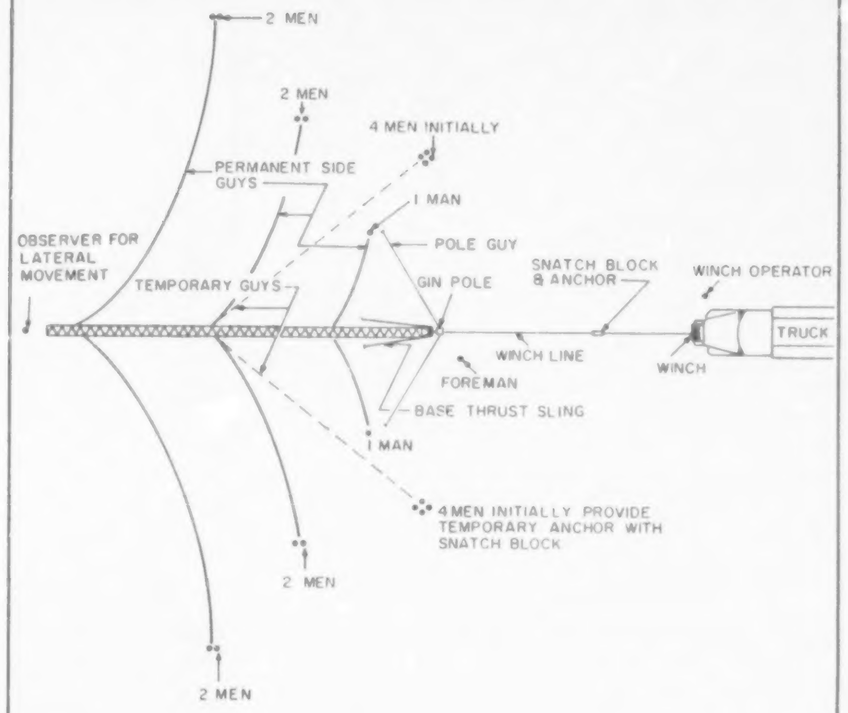

2 MEN
2 MEN
4 MEN INITIALLY
PERMANENT SIDE GUYS
1 MAN
POLE GUY
OBSERVER FOR LATERAL MOVEMENT
TEMPORARY GUYS
GIN POLE
SNATCH BLOCK & ANCHOR
WINCH OPERATOR
TRUCK
WINCH LINE
WINCH
FOREMAN
BASE THRUST SLING
1 MAN
4 MEN INITIALLY PROVIDE TEMPORARY ANCHOR WITH SNATCH BLOCK
2 MEN
2 MEN

FIGURE HF-10. ERECTION PLAN FOR PIVOTED TOWER.

guidance

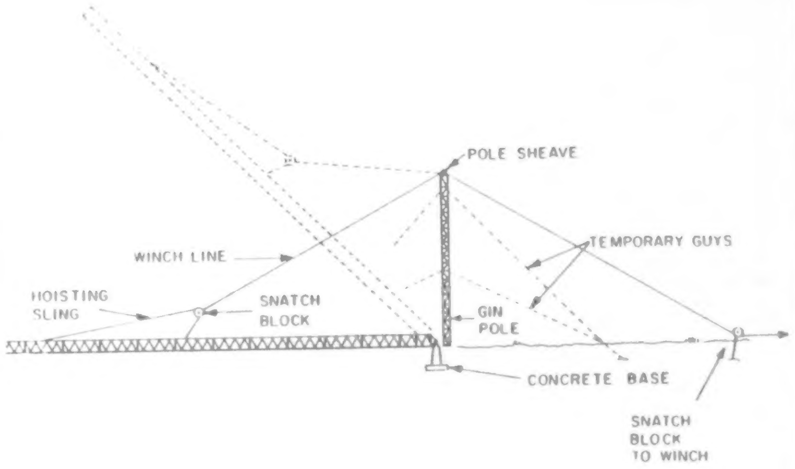

POLE SHEAVE
TEMPORARY GUYS
WINCH LINE
HOISTING SLING
SNATCH BLOCK
GIN POLE
CONCRETE BASE
SNATCH BLOCK TO WINCH

FIGURE HF-11. ERECTION OF PIVOTED GUYED TOWER.

guidance

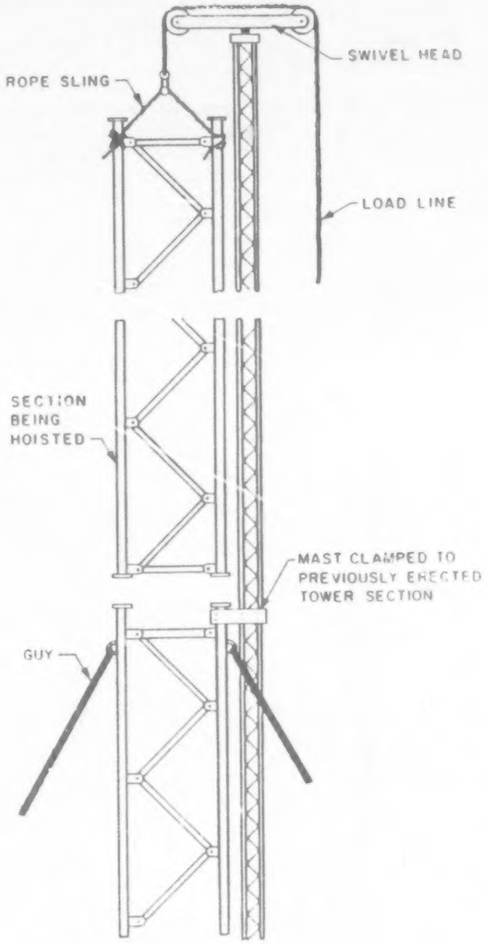

SWIVEL HEAD
ROPE SLING
LOAD LINE
SECTION BEING HOISTED
MAST CLAMPED TO PREVIOUSLY ERECTED TOWER SECTION
GUY

FIGURE HF-12. TOWER ERECTION WITH AUXILIARY MAST.

guidance

11. Freestanding towers

Figure HF-13 shows a typical individual foundation for a freestanding tower and Figure HF-14 shows a foundation plan for a triangular steel freestanding tower. Bracing and material specifications for these towers are the same as for guyed towers. Figure HF-15 shows base supports for guyed towers. (68) 7-5

Self-supporting towers are erected most effectively using a mobile crane if the tower height is within the crane's height range. For high towers, the lower portion can be erected with a crane and the upper section can be handled with the basket boom rig shown in Figure HF-16. The pole for the basket boom is supported at the top and bottom by guys attached to the column struts with reeved blocks. This is a flexible arrangement that facilitates erection by allowing the pole to be moved quickly to any work location. When cross obstructions hinder hoisting, the pole can be placed at an angle to raise material outside the structure. When erection of the structure has reached a height at which the gin pole is no longer useful, the pole must be lifted to a new position at a higher level. (68) 7-9.

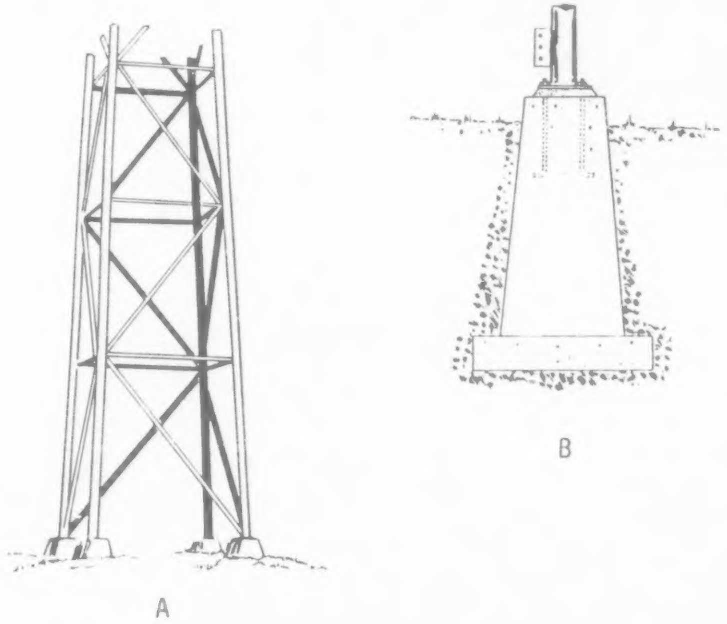


FIGURE HF-13. A - SQUARE SELF-SUPPORTING TOWER AND B - SELF-SUPPORTING TOWER BASE.

guidance

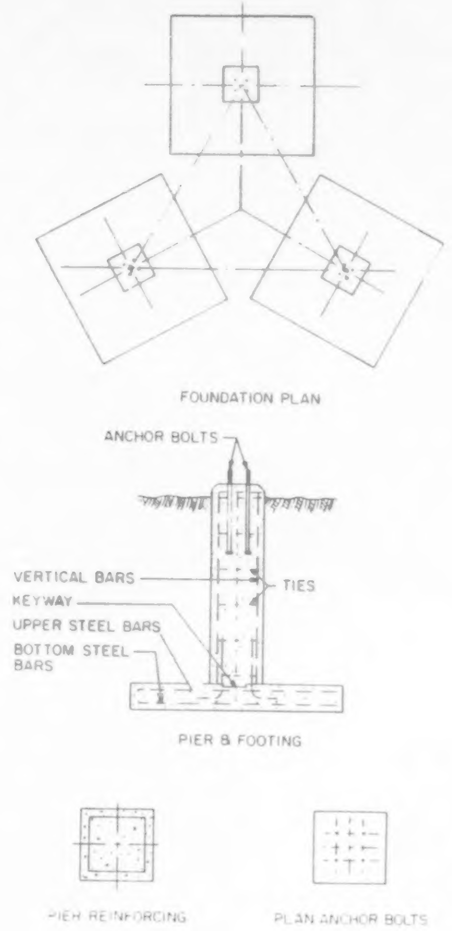
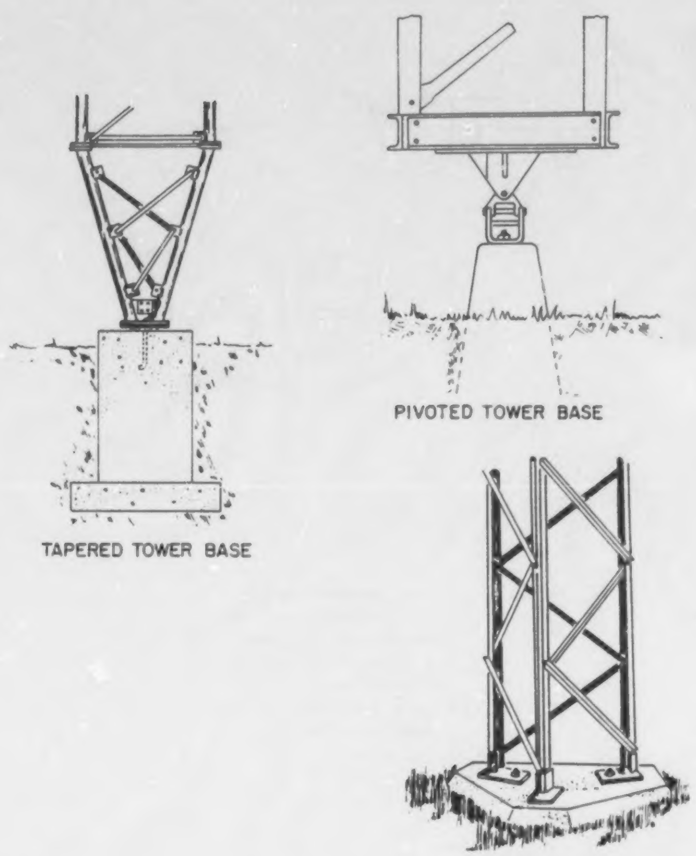

FOUNDATION PLAN
ANCHOR BOLTS
VERTICAL BARS
KEYWAY
UPPER STEEL BARS
BOTTOM STEEL BARS
TIES
PIER & FOOTING
PIER REINFORCING
PLAN ANCHOR BOLTS

FIGURE HF-14. TRIANGULAR TOWER FOUNDATION.

guidance



TAPERED TOWER BASE

PIVOTED TOWER BASE

COMPOSITE BASE

FIGURE HF-15. BASE SUPPORTS FOR GUYED TOWERS.

best copy available

guidance

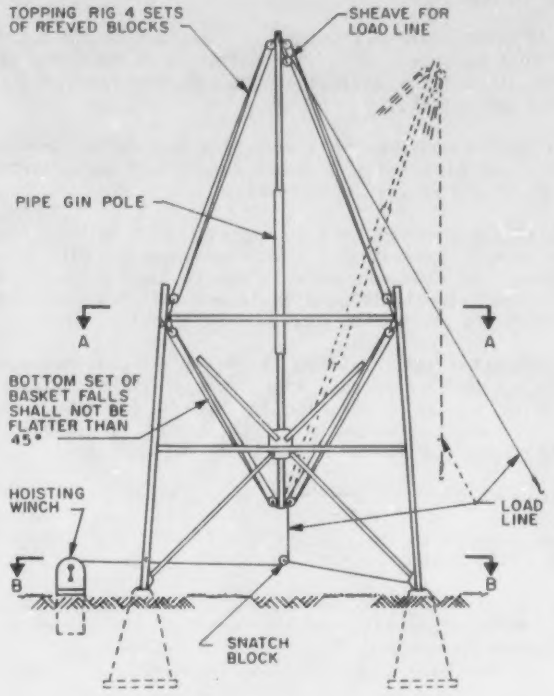
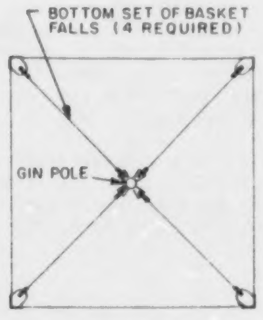
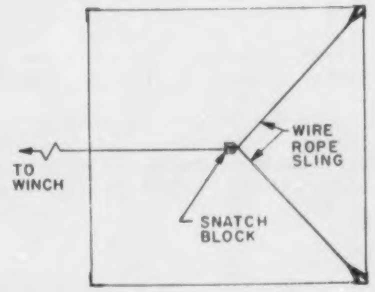

TOPPING RIG 4 SETS OF REEVED BLOCKS
SHEAVE FOR LOAD LINE
PIPE GIN POLE
A
A
BOTTOM SET OF BASKET FALLS SHALL NOT BE FLATTER THAN 45°
HOISTING WINCH
LOAD LINE
B
B
SNATCH BLOCK

FIGURE HF-16. BASKET BOOM FOR ERECTING SELF-SUPPORTING TOWERS.


BOTTOM SET OF BASKET FALLS (4 REQUIRED)
GIN POLE

PLAN AT A-A


WIRE ROPE SLING
TO WINCH
SNATCH BLOCK

PLAN AT B-B

12. Central dry air system

Many types of devices are available for providing dehydrated, pressurized air for this purpose. At a transmitting station where several coaxial lines are used, it is advisable to pressurize the lines from a single central dry air system.

The dry air system consists of a source of pressurized air, a way to filter and dry the air, and a pressure regulating and distribution system (Figures HF-17 and HF-18). (46) 4-A1-1

Pressurized air is provided by two compressors (1 in both figures) and air receiver tank (2) assemblies connected together with a common output. The normal air flow requirements can be supplied by a single assembly. The second assembly is used to insure additional air flow in case of an emergency and to provide increased reliability. (46) 4-A1-1

Compressor operation is controlled by individual pressure-operated switches (4) attached to each storage tank. One pressure switch assembly (4) (low limit) is set to operate between 40 and 60 pounds per square inch gravity, and the second one (high limit) is set to operate between 60 and 80 pounds per square inch gravity. (46) 4-A1-1

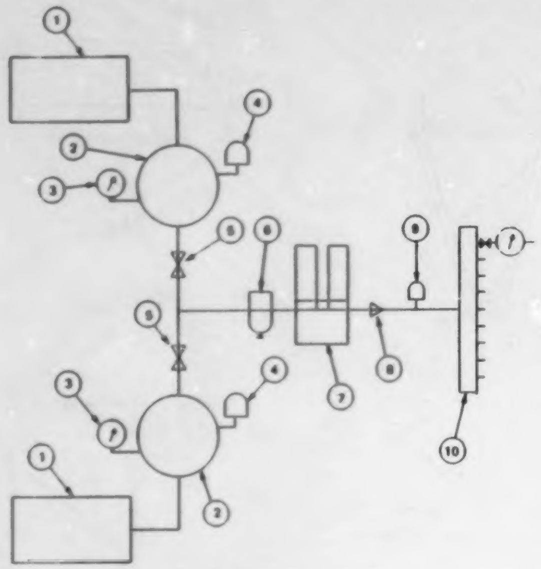
Under normal dry-air requirements, only the high-limit switch assembly will operate. The low-limit switch assembly will cut in and operate the reserve compressor only if the air flow exceeds the capacity of a single unit. (46) 4-A1-1

So that the operating time and wear are divided equally between the two compressors, the pressure switches are connected through an automatic alternator switch assembly. This assembly automatically operates each compressor in turn each time additional storage air is required. (46) 4-A1-1

Compressor motor starting contactors provide hand starting for both compressors, automatic starting, and an "off" position. These provisions are useful when maintenance or repair is required. (46) 4-A1-1

Pressurized air from the storage tank is piped to a regulatory-filter unit (6). This unit removes free oil and water droplets from the air stream and regulates the output air pressure to 30 pounds per square inch gravity. This air supplies the pure-gas air dryer (7) which removes virtually all water vapor from the air. The air being dried is valved automatically through the dehydrator unit by a timing motor and switch assembly located in the base of the air dryer. (46) 4-A1-4

Operation of this motor is controlled by a pressure switch (9) at the input side of the air distribution manifold (10). This switch is set so the dehydrator cycles only when the pressure at the air distribution manifold is less than 18 pounds per square inch gravity. (46) 4-A1-4



1. AIR COMPRESSOR, OIL-LESS
2. AIR RECEIVERS, 30 GALLONS
3. PRESSURE GAUGE 0 - 100 LBS.
4. PRESSURE SWITCH
5. SHUT-OFF VALVE
6. FILTER REGULATOR
7. PUREGAS AIR DRYER
8. CHECK VALVE
9. PRESSURE SWITCH
10. GAS DISTRIBUTION MANIFOLD

FIGURE HF-17. AIR FLOW DIAGRAM OF CENTRAL DRY AIR SYSTEM.

Air in the distribution manifold is piped to coaxial patch panels as appropriate and then regulated and metered in the usual way. (46) 4-A1-4

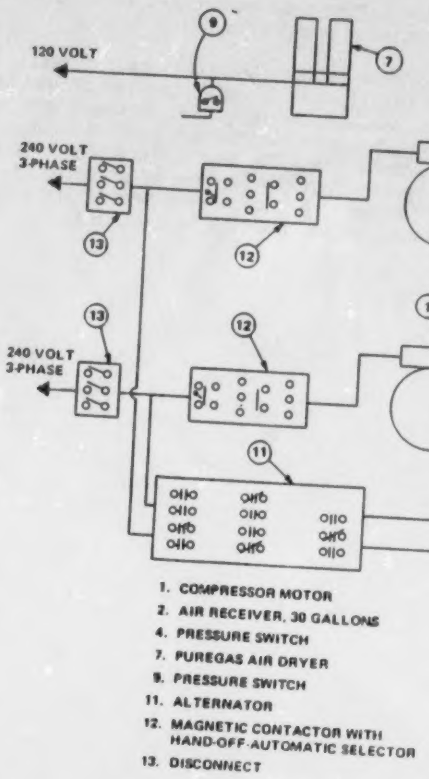


FIGURE HF-18. ELECTRICAL BLOCK DIAGRAM OF CENTRAL DRY AIR SYSTEM.

14. Transmission line maintenance

Antenna maintenance personnel should make a complete weekly check of pressurization as follows:

- At the transmission line dry-air manifold, turn on the compressor and pump the lines to about 10 pounds. Observe the gages and record the pressure on each line.
- Shut off the dry air feed to the lines.
- After a 24-hour period, observe gages and record their value. Pressure should be maintained between 5 and 10 pounds. If not within this range, the line or lines should be investigated for leaks.
- Open the dry air valve to maintain automatic pressure. Unless the transmission line is physically damaged, a leak usually is associated with a splice. Therefore, the antenna maintenance crew should maintain a list indicating which transmission lines have splices, the number of splices in each line, and the approximate distance from the antenna. It is also worthwhile to physically mark the splices with a post of some type.

When transmission line trouble is suspected, a fault finder (Time Domain Reflectometer--TDR) should be used to determine the distance to the fault. For example, if the line will not hold proper pressure, indicating a leak, this area will show as a discontinuity because of moisture in the line. The TDR will indicate this fault and its distance from the antenna. (46) 3-2

If the transmission line is above ground, locating the fault visually will be a simple matter. If the cable is buried, it will be necessary to refer to cable installation drawings to determine the cable's routing and the approximate area of the fault; a cable fault locater (such as Hewlett Packard Model 4904A) is then used to determine the exact location of the fault. This type of cable fault locator consists of a transmitter to feed a pulsed audio signal into the line, a sensitive receiver tuned to the transmitter signal, an inductive search wand to pick up the signal over the cable path, and a similar capacitive contact frame for locating faults through voltage variations. (46) 3-5

Splicing of heliax cable is the antenna maintenance crew's responsibility. It must be done professionally, following the cable manufacturer's procedures to insure an airtight, moisture-proof connection as well as to provide for the transmission line's electrical continuity. (46) 3-5

Once a splice has been made in a transmission line, a voltage standing wave ratio (VSWR) test must be done before putting the line back in service and applying power.

guidance

Coaxial line used at receiver sites is usually the solid dielectric "RG" type. It requires no pressurization and, because no high voltages are present, is usually trouble-free unless physically damaged. Here again, a record should be kept of all splices and their location in case of a fault. (46) 3-5

A considerable amount of open wire transmission line is still in use at Naval communications stations worldwide. These lines should be inspected periodically--usually at the time the associated antenna is inspected. The spacers and insulators should be cleaned, all connections should be checked, and any slack should be taken out of the line. (46) 3-5

When copperweld wire has been used on very long lines, the line's constant vibration will wear away the copper where the wire passes through the candlestick insulator. When this happens, the steel part of the line will be exposed and start to rust. To prevent breakage, a close inspection is necessary; the wire should be replaced if it shows excessive wear at the insulator points. (46) 3-5

15. Lightning rod systems

Lightning rod systems are relatively simple protective grounding systems used to provide a low-resistance, low-inductance path to the earth. They are used mainly on wooden support poles. A typical installation consists of a lightning rod mounted on the top of the pole, a down-conductor wire, and a ground rod. (68) 6-22

Lightning rod systems are not needed on metal support towers if the tower structural members' resistance, measured from top-to-base, is 20 ohms or less. A tower can be grounded by connecting any convenient point on the tower to a ground rod. (68) 6-22

A satisfactory lightning rod system can be obtained using the following guidelines:

- Make the lightning rod from copper or copper-clad steel at least 3/4 inch in diameter and 5 feet long. Install the rod so that it will project 2 feet or more above the top of the pole.
- For the down-conductor wire, use at least No. 2 AWG copper or copper-clad steel wire to give the necessary low-resistance, low-inductance path to ground. The down-conductor wire must be a straight, continuous length from the lightning rod connection to the ground rod. On wooden poles, this continuous length should never be broken up with discharge gaps since an arcing gap could set the pole on fire. At connection points and at points where changes of direction are unavoidable, bending radii of the wire must be at least 8 inches and the bend must be no greater than 90 degrees.

guidance

- If other metal objects such as hoisting arms or obstruction lights are installed on top of the pole, ground them by connecting them to the down-conductor with wire of the same size and type as the down-conductor. Run power wiring to these objects in metal conduit bonded to the down-conductor at random intervals of not more than 10 feet.
- Use copper or bronze bolted-type connectors to secure the down-conductor to the lightning and ground rods.
- Make the ground rod from copper-clad steel rod at least 3/4 inch in diameter and 10 feet long. Ideally, the rod should be set in the ground so that its entire length is below grade. If the desired depth cannot be reached and the depth of refusal is so shallow that the ground rod will be ineffective, an acceptable protective ground termination can be made by wrapping at least 25 feet of No. 2 AWG (or larger) copper wire around the base of the structure at the lowest point possible below grade.

guidance

The down-conductor and ground rod should be interconnected below grade as shown in Figure HF-19.

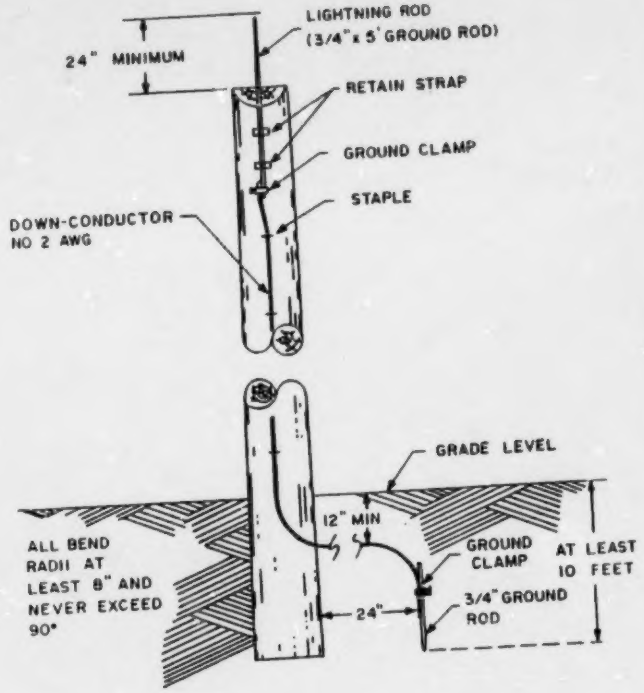


FIGURE HF-19. LIGHTNING ROD SYSTEM.

guidance

Discharge gaps are installed at the junction of the antenna and transmission line to protect HF antennas and their components against high-voltage surges from lightning. Gaps should also be installed across the terminating resistance of terminated antennas and at the point where the open-wire transmission lines enter the building. (68) 6-24

The three basic types of discharge gaps are: point, ball, and horn. All three serve the same purpose in that the gap resistance breaks down and permits current flow to the earth in case of a lightning strike, thus providing a degree of overvoltage and current protection to the connected equipment. (68) 6-24

The point gap device will break down at a lower voltage than the others, so it is generally well suited for receiving antennas. The ball gap has roughly three times the breakdown voltage rating of the point gap, and it can be used on either receiving or transmitting antennas. The horn gap is the most commonly used of the three types. It has approximately the same breakdown voltage rating as the ball gap, and it is self-quenching; that is, transmitter RF power will not sustain an arc across the electrodes. (68) 6-24

The gap electrodes are made from nickel-plated brass rod or hard-drawn solid copper at least 1/4 inch thick, and the electrodes are connected to antenna down-leads, down-conductor wires, or other conductors with copper or bronze bolt-type connectors. The requirements for the down-conductor and the ground rod are the same as those for a lightning rod system. (68) 6-24

The minimum voltage at which the gap will break down and divert current flow to ground is determined by the electrode spacing. The desired breakdown voltage is attained by spacing the electrodes at the distance for which the full power output of the transmitter (at 100 percent modulation) produces an arc and then by increasing the space an additional 1/4 inch. (68) 6-24

guidance

Figure HF-20 shows a typical horn gap installation for antenna down-leads.

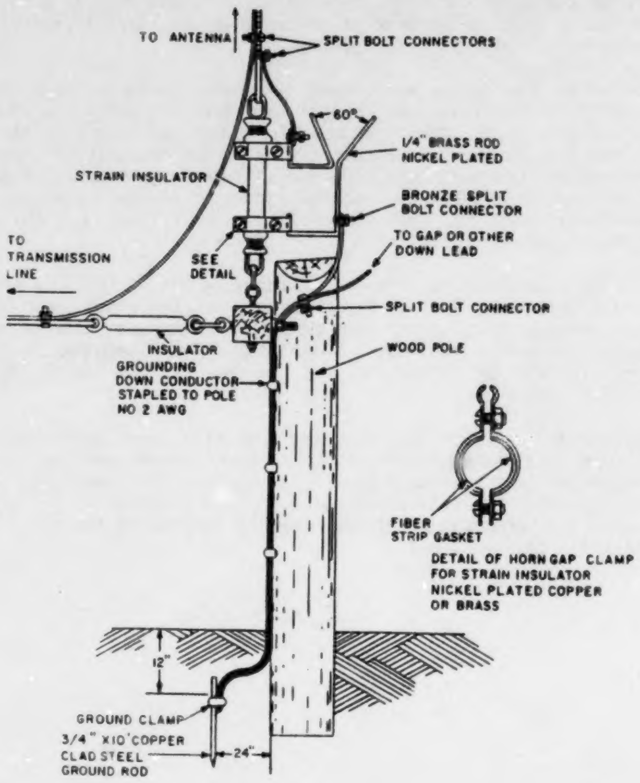

TO ANTENNA
SPLIT BOLT CONNECTORS
60°
1/4" BRASS ROD NICKEL PLATED
STRAIN INSULATOR
BRONZE SPLIT BOLT CONNECTOR
TO GAP OR OTHER DOWN LEAD
TO TRANSMISSION LINE
SEE DETAIL
SPLIT BOLT CONNECTOR
INSULATOR
WOOD POLE
GROUNDING DOWN CONDUCTOR STAPLED TO POLE NO 2 AWG
FIBER STRIP GASKET
DETAIL OF HORN GAP CLAMP FOR STRAIN INSULATOR NICKEL PLATED COPPER OR BRASS
12"
GROUND CLAMP
3/4" X10' COPPER CLAD STEEL GROUND ROD
24"

FIGURE HF-20. HORN GAP USED WITH ANTENNA DOWN-LEADS.

guidance

Antenna description: AS-1862/FRC

The AS-1862/FRC is a horizontally polarized, unidirectional, log periodic, dipole antenna suitable for transmitting and receiving on medium- and long-range circuits. Since it can rotate in 30-degree increments throughout the full 360-degree azimuth, it can be considered a general purpose antenna for point-to-point communications. Its frequency range is 6.5 to 30 megahertz. Structurally (Figure HF-21), the antenna (1) is supported by an 80-foot galvanized steel mast (2). The mast mounts on a rotor (3) that pivots between two 80-foot galvanized steel towers (4). The towers are connected together at the top by a bearing assembly that secures the mast section for rotation. The twin towers are guyed on top at 90-degree intervals by 1/2-inch insulated steel guy lines. The antenna proper consists of a 66-foot aluminum angle boom that supports the antenna's 16 elements. Each element is insulated from the boom by two fiberglass angles. The elements themselves are constructed of aluminum tubing or rods and are insulated at the center by a fiberglass tube. The rotor assembly in the LPH-9 will automatically position the antenna in 30-degree increments of azimuth. Because a rotating joint is used in the coaxial line, continuous positioning is possible in either direction with no limit switches or stops needed. Mechanically, the rotor consists of a 1/2-horsepower, single-phase, capacitor-start electric motor that drives a double worm-gear reduction box. A chain drive is used from the gear box to the antenna mast; this provides an additional reduction of 2.5 to 1, making the antenna rotation speed 1 revolution per minute. (46) 5-1-3

Electrically, the antenna is frequency-independent. That is, it is able to transmit or receive over a broad range of frequencies (6.5 to 30 megahertz). This is possible because the elements' length and spacing between them vary logarithmically such that any part of the antenna simply becomes a scale model of any other part (from which comes the name "log periodic"). (46) 5-1-3

To insure its frequency independence, a log periodic antenna must be fed from and radiate toward the small element end. This is done on the LPH-9 in a rather complicated way. The antenna is fed at the base of the mast through a 1-5/8-inch coaxial line suspended on springs inside the mast section, and a rotating coaxial joint allows the antenna to be fed at any position of azimuth. When the transmission line reaches the rear of the antenna, it is connected to another coaxial line extending down the boom to the front. At the front, the center of the coax is connected to a dummy line extending back to the rear of the antenna. Current from the inner conductor of the coax flows onto the dummy. Since the outer conductor of the coax feed line has no connection, the current folds over and flows back down the outside of the conductor. Thus, an unbalanced to balanced transformation occurs. Energy is transmitted to the elements by the balanced line consisting of the dummy line and the outer conductor of the coax. As the phase is reversed between each element by criss-cross feed connections, the energy is redirected toward the front of the antenna, giving it a power gain of approximately 14 decibels over a single dipole. (46) 5-1-3

For more information, see Technical Manual for Rotatable Log Periodic Antenna System Type LPH-9, Antenna Products Company, Mineral Wells, Texas.

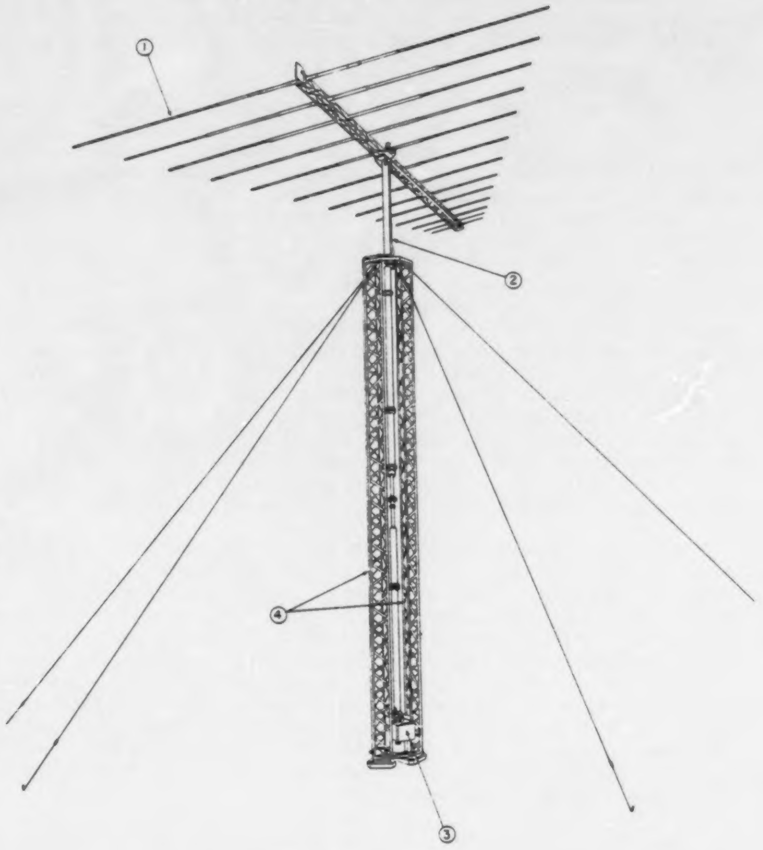


FIGURE HF-21. AS-1862/FRC ANTENNA.

Antenna description: AS-2187/FRC

The AS-2187/FRC is a horizontally polarized, unidirectional, rotatable log periodic antenna. Because of its log periodic construction, for which the theory was explained in the description of the LPH-9 antenna, it is essentially frequency-independent and able to transmit cr receive radiofrequency energy in the 5.5 to 3.2 megahertz range without adjustment. (46) 5-2-3

A remote position control unit in the transmitting or receiving building controls the antenna's location and position. A local position control is at the base of the tower for use by maintenance personnel. (46) 5-2-3

The antenna itself (Figure HF-22) is a triangular-shaped, wire-strung array with fiberglass catenaries (1); it is supported by an aluminum structure consisting of three horizontal booms (2) attached to a center hub; the apex of the array, which is the stem of the Y, points toward the direction of radiation. The array is mounted on the rotor assembly (3) which is located, unlike other types of rotatable log periodics, at the top of a 100-foot steel support tower (4). The rotor assembly consists of a large-diameter combination support bearing ring gear, pinion gear assembly, torque-limiting slip clutch, reversible worm-gear motor, and limit switch assembly that control the position of the antenna and thus the direction of transmission or reception. In response to a command from the local or remote position control, the rotor assembly rotates the antenna to any desired position. The limit switches will stop rotation after 180 degrees in either direction from a predetermined point. The rotor is hinged at the top of the tower so the array can be folded over the tower when it lays on the ground. (46) 5-2-3. The array, the rotor assembly, and the support tower are designed to be raised and lowered as one unit. (46) 5-2-3

A unique feature of this antenna is that it does not use a rotating coaxial joint. Instead, a four-wire feedline runs up the center of the tower. The upper end of the line extends through the rotor and turns with the array. The lower end of the line terminates at a structural bracket at the tower base. This, in turn, is connected to a matching transformer and then to the coaxial line extending from the transmitter or receiver building. Clockwise or counterclockwise rotation is provided by the feedline, which twists only 180 degrees in either direction from its neutral position. A matching unit is located at the tower base and connects a 50-ohm coaxial input to the 200-ohm balanced four-wire feedline of the antenna itself. (46) 5-2-3

For more information, see the Technical Manual for Rotatable Log Periodic Antenna, AS-2187/FRC (Granger Associates), NAVSHIPS 0967-871-5500 and the Maintenance Standard Book for Antenna, AS-2187/FRC, NAVSHIPS 0967-871-5520.

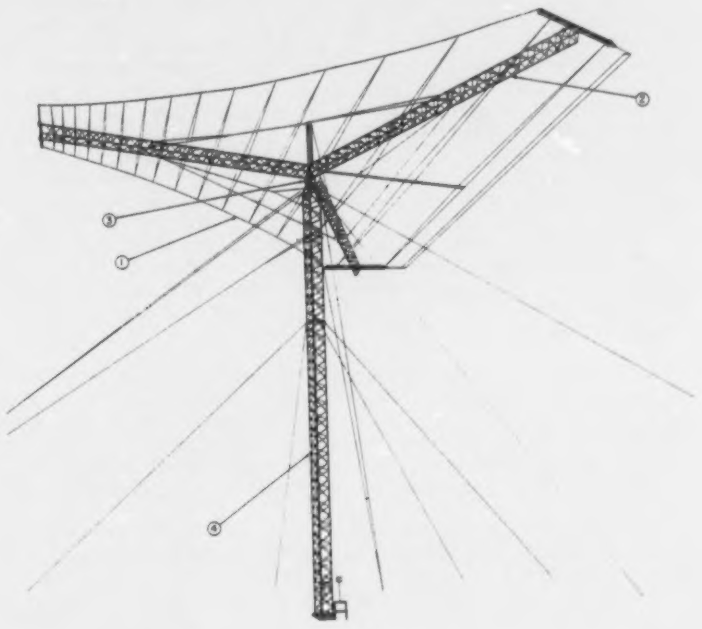


FIGURE HF-22. AS-2187/FRC ANTENNA.

Antenna description: Collins 237A

The Collins 237A series of high-frequency, horizontal, log periodic antennas come in three models to cover a total frequency range of 6.5 to 60 megahertz. They are identical except for size (Figure HF-23). The largest (237-1A) covers the range 6.5 to 58 megahertz. Its boom length is 52.5 feet and the length of the longest (rear) element is 70 feet. The 237A-2 covers the 11.1 to 60 megahertz range and has a boom length of 41 feet; the longest element is 46.8 feet. The 237A-3 operates in the 19 to 60 megahertz range with a boom length of 24.5 feet and a rear element length of 28.1 feet. (46) 5-3-3

The antennas are unidirectional and can be rotated through 360 degrees of azimuth with a rotor assembly and rotating coaxial joint. They are suitable for general purpose point-to-point communications on the medium- and long-range circuits. (46) 5-3-3

Structurally, the antennas are composed of tubular aluminum elements (1 in Figure HF-23) and aluminum and galvanized steel booms (2) with the elements arranged in two planes of a triangle separated by an included angle of 37 degrees. (46) 5-3-3

The elements are attached to each boom with U-bolts through a rectangular mounting plate. Elements longer than 6 feet are step-tapered in size, and adjacent element ends are connected alternatively with aluminum tube jumpers (3). Ceramic insulators are used to connect the booms together rigidly at the feed point. (46) 5-3-3

The antenna is mounted on a rotatable, vertical mast (4), with a rotor assembly (5) consisting of a motor, gear reducer, and chain drive located at the base of the mast. The rotating coaxial joint is located just below the rotator assembly. (46) 5-3-3

The entire rotating mechanism is suspended by a trunnion mount between two guyed steel towers (6) (utility poles are sometimes used). The mast is secured at the top of the towers by a split bearing assembly, one-half of which is removable. This type of mounting allows the antenna and supporting mast to be tilted up or down without using heavy equipment. (46) 5-3-3

The lower half of the antenna is fed against the upper half at the vertex by a coaxial line contained in the lower boom. The boom itself acts as the outer conductor of the coaxial line. Since the antenna's characteristic impedance is approximately 150 ohms, the center conductor within the boom is step-tapered to transform this impedance to 50 ohms at the feed point. The mast below the lower boom forms the outer conductor of the coaxial feedline from the base. (46) 5-3-3

For more information, see the Instruction Book for Unidirectional HF Antennas, 237A-1A, 237A-2, and 237A-3, Collins Radio Company, Cedar Rapids, Iowa.

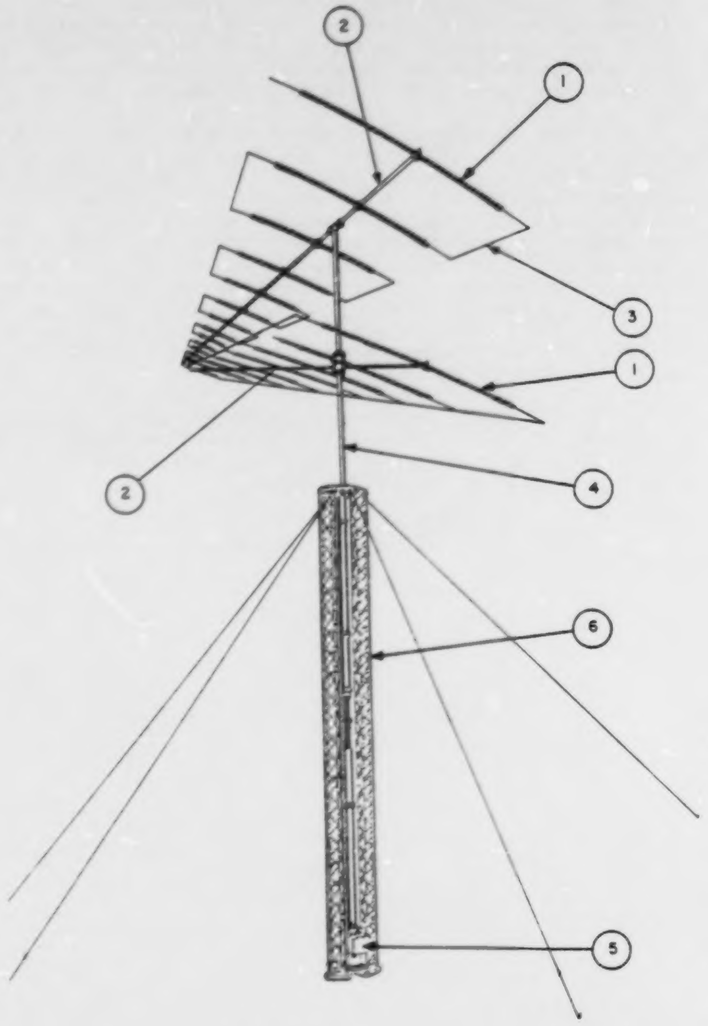


FIGURE HF-23. COLLINS 237A ANTENNA.

Antenna description: Inverted cone

All inverted cone antennas have identical construction, differing only in size because of their frequency range. The antennas are vertically polarized, broadband, and omnidirectional; they transmit or receive signals in the 2- to 32-megahertz range. These antennas are suitable for medium- to long-range communications with ships, aircraft, or other ground installations. (46) 6-3

This type is essentially a monopole antenna in the form of a single inverted cone of hexagonal cross-section with a ground plane (Figure HF-24). The cone consists of 60 evenly spaced wire radiators supported by six catenaries (1); the radiators are attached to a metal ring at the apex of the cone (2). The complete cone assembly is supported by six wooden poles (3) with guys spaced evenly about the hexagon. The ground screen, consisting of 120 evenly spaced radials (4) extending from the apex, provides a ground plane that improves the antenna's efficiency and low-angle radiation characteristics. The antenna is fed at the apex ring by an impedance matching coupler between the antenna terminals and the coaxial transmission line. (46) 6-3

For more information, see the Technical Manual for Antennas, AS-2212/FRC, AS-2213/FRC, AS-2214/FRC (Granger Associates), NAVSHIPS 0967-294-6010, and Maintenance Standards Book, AS-2212/FRC, AS-2213/FRC, AS-2214/FRC (Granger Associates).

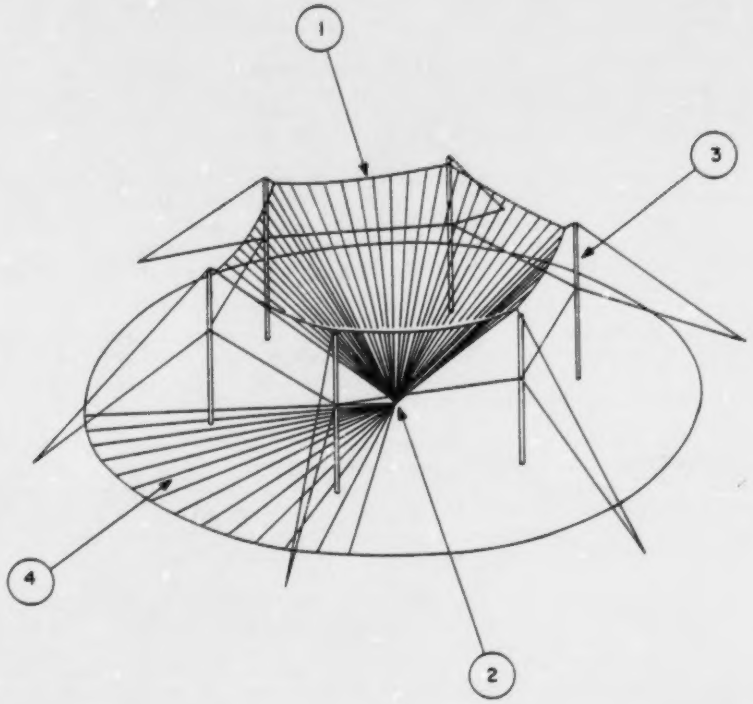


FIGURE HF-24. INVERTED CONE ANTENNA.

systems 3. Conical Monopole Antennas

Antenna description: Conical monopole

The conical monopole antenna is structurally one of the simplest antennas used by the Naval Communications Command. It is a broadband, omnidirectional antenna used for medium-range, ground-to-air, and shore-to-ship transmissions. Conical monopole antennas are all basically the same configuration, and differ in size depending on the design frequencies. The antenna consists of a central aluminum tower (Figures HF-25 and HF-26) supporting two cones mounted back to back to form a wire cage structure (1 in both Figures). The lower cone has more radiators than the upper. The antenna is fed at the base by a coaxial line (2). A ground screen (3), in the form of wires extending from the base, is an integral part of this antenna. (46) 7-5

For more information, see the Technical Manual for Conical Monopole Antenna, AS-2205/FRC, NAVSHIPS 0967-276-4010 (H7-Gain Corp.), and the Technical Manual for Conical Monopole Antennas, AS-1973-1975/FRC (Granger Associates).

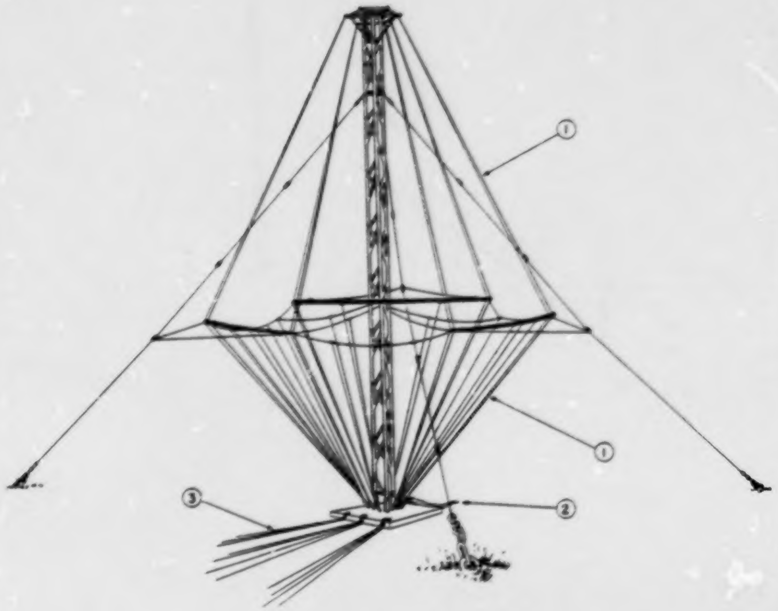


FIGURE HF-25. CONICAL MONOPOLE - AS-1973-1975/FRC (GRANGER ASSOC.).

systems 3. Conical Monopole Antennas

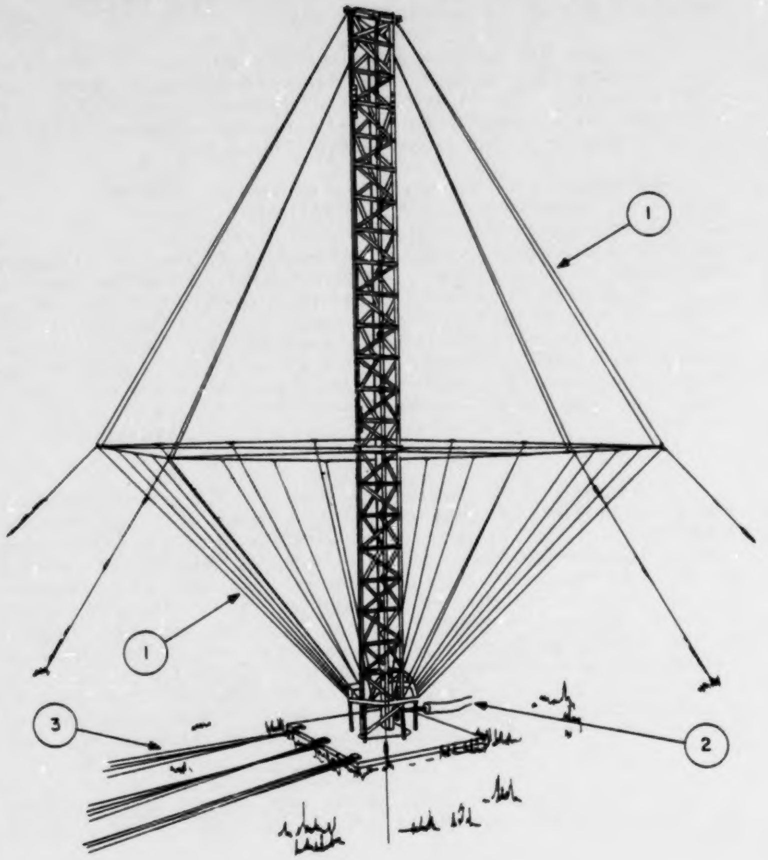


FIGURE HF-26. CONICAL MONOPOLE - AS-2205/FRC (HY-GAIN CORP.).

systems 4. Fixed Vertical Log Periodic Antennas

Antenna description: Fixed log periodic

The fixed LPAs described here are unidirectional, vertically polarized, broadband antennas used for either transmitting or receiving on point-to-point or sector coverage service at long distances. Under typical conditions, their effective range is about 1200 miles when operating over average ground; this can increase to 2000 miles when operating over seawater or when the antenna is equipped with a ground screen. (46) 8-3

Like other log periodic antennas, they can transmit or receive over a broad frequency range. This family of antennas comes in four different sizes. The largest, with a frequency range of 4.0 to 32 megahertz, has 18 radiators; the smallest, with a frequency range of 6.5 to 32 megahertz, has 15 radiators. (46) 8-3

The antenna is connected to the coaxial transmission line through an impedance matching unit (balun). These are air-cooled for receiving circuits and oil-cooled for transmitter circuits. The signal is fed through the balun and applied to the high-frequency (small) end of the feedline. The signal travels along the feedline until it encounters several radiating elements that are nearly resonant. Most of the energy is extracted from the feedline at this point and launched into space. The size and spacing of the surrounding radiating element reinforce the signal's phase in the direction of radiation, which is always toward the antenna's small end. Since the radiating element array is slanted with respect to the earth, the signal's vertical or take-off angle remains constant over the antenna frequency range. (46) 8-3

Structurally, the antenna (Figure HF-27) consists of a radiating curtain made up of a fiberglass catenary (1) and drop rod assembly (2). The radiators (3), with the feedline (4) running through their center, are secured to eyebolts embedded in concrete through a cable and insulator assembly (5). The back (low-frequency end of the antenna catenary is attached to a triangular, guyed aluminum tower (6), whereas the front (high-frequency) end fastens to the front pole (7) by galvanized steel eyebolt. The antenna is brought into proper tension by turnbuckles at the front end of the catenary and feedline. The back end of the feedline is joined into a common cable and grounded to the tower. The matching unit or balun (8) is mounted on a pole near the front of the feedline. (46) 8-3

For more information, see the Technical Manual and Parts List for Granger Associates, Model 1703-I to 1703-4, Log Periodic Antennas.

systems 4. Fixed Vertical Log Periodic Antennas

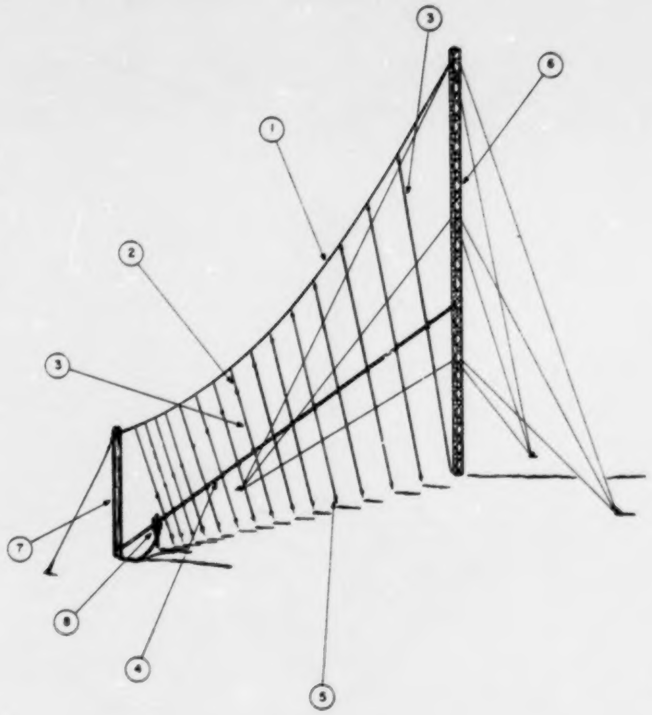


FIGURE HF-27. FIXED VERTICAL LOG PERIODIC ANTENNA.

Antenna description: Fixed horizontal LPA

The Granger Series 1701 and 1702 fixed horizontal log period high frequency antennas described in this section are unidirectional and broadband. They can be used for either transmitting or receiving, depending on the type of impedance matching unit (balun) furnished. (46) 9-3

The series 1701 antennas are designed for short-range (60 to 850 miles), point-to-point communication and use a shorter tower than the series 1702. This makes the angle of the radiating curtain lower with respect to the ground which, in turn, provides the higher signal takeoff angle needed to insure short-range coverage. The series 1702 designed for the point-to-point medium ranges (20 to 1200 miles) has a higher tower; thus, the curtain is more steeply inclined to the ground and the signal takeoff angle is lower. (46) 9-3

The 1701 and 1702 series antennas both come in a variety of sizes, depending on the frequency required. The smallest size has a frequency range of 6.5 to 32 megahertz; the largest covers 2.5 to 32 megahertz. (46) 9-3

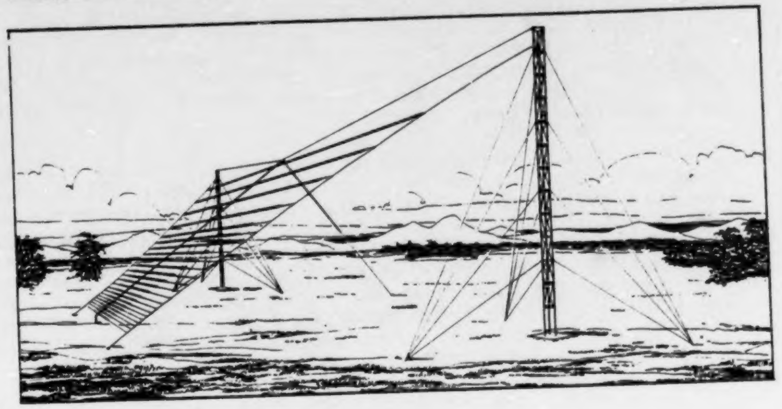
The geometry of these antennas, like the other log periodic types discussed in this guide, is such that the electrical properties repeat periodically with the driving frequency logarithm. Since the spaces between the radiating elements and the length of adjacent elements are small, the antenna's impedance and directional properties are essentially independent of frequency. It is fed at the high-frequency end in the same way as other LPAs. (46) 9-3

Structurally, the antenna (Figure HF-28) is supported by two guyed aluminum towers (1 in Figure HF-28) of triangular cross section that support radiating curtain catenaries at the low-frequency end. The front end of the catenaries fastens to galvanized steel anchors imbedded in concrete. (46) 9-3

The radiating curtain consists of the feedline (2) and radiators (3) attached to the fiberglass catenaries (4) by fiberglass drop rods. An insulated cable with a turnbuckle fits to the front of the feedline (5). The turnbuckle hooks onto a galvanized steel anchor imbedded in concrete. At the rear of the antenna, the two feedlines join together just beyond the longest radiators and attach through a structural fuse (6) (load relief device) to galvanized steel anchors imbedded in concrete. The structural fuse consists of three stainless steel links held together by a piece of copper wire. If stresses on the antenna become too great, the links shear the copper wires and the feedline tail loosens from its anchor, releasing tension throughout the antenna. (46) 9-3

The antenna is adjusted to proper tension by the turnbuckles at the front end of the feedline and catenaries. The impedance matching unit (7) is mounted on a pole set near the front end of the feedline. (46) 9-4

For more information, see the General Instruction Manual for Granger Associates Series 1701/1702 Horizontally Polarized Log Periodic Antennas.



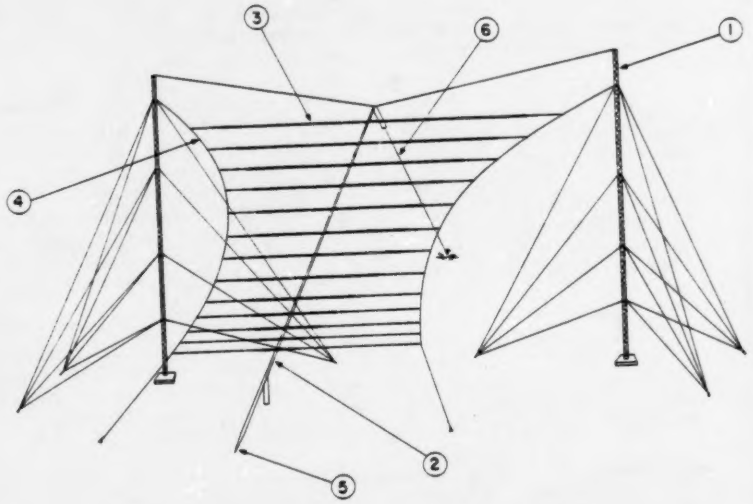


FIGURE HF-28. FIXED HORIZONTAL LOG PERIODIC ANTENNA.

Antenna description: Rhombic

The rhombic antenna consists of four long-wire radiator elements arranged in the shape of a rhombus. This antenna is simple to erect, has high gain, is unidirectional when terminated properly, and provides good performance over a broad, continuous frequency range. These characteristics explain the continued wide use of these antennas throughout the Navy, despite the fact that they take more real estate and provide less discrimination than the newer, more sophisticated LPAs. (46) 10-3

Most rhombic antennas used by the Navy at permanent sites are designed individually for the circuit in which they will be used. The exact great circle distance and all operating frequencies for that circuit are considered. From this, the wave angle, which is the angle of radiation or arrival of the optimal propagation path, is determined. The wave angle is then used to determine the three dimensions for the rhombic antenna--leg length, height above ground, and tilt angle (one-half the inside angle between the wires at the side poles of the antenna). From any one wave angle, there is one set of three dimensions that gives maximal output. (46) 10-3

Structurally, the antenna (Figure HF-29) is supported by four poles (1), although in some cases, metal towers are used. The three conductors of the radiating element (2) are brought together at the front and rear apexes and are separated by several feet at the side poles to form a curtain. To keep the tension on the curtain uniform, counterweights are sometimes used at the end poles. The three-wire curtain shown has an input impedance of approximately 600 ohms and is fed at the rear end. The front or far end, which is in the direction of maximum transmission or arrival, is usually terminated in its characteristic impedance by a resistor; this makes the antenna unidirectional and nonresonant. (46) 10-3

The major difference between receiving and transmitting rhombics is how much power they can handle (Table HF-9). The insulators for a transmitting rhombic are larger than those for a receiving rhombic. The termination resistors used with receiving rhombics are ordinarily small enough that they can be installed in small, waterproof boxes at the top of the antenna end pole. The termination resistance (3) for a transmitting rhombic must absorb considerable power and is generally a stainless steel dissipation line run back and forth in clothesline fashion under the antenna. (46) 10-3

The antenna can be fed by a 600-ohm, open-wire transmission line (4) or by a coaxial line, provided a suitable impedance matching transformer is used. Many installations use a combination, leaving the building with a coaxial line, then transforming and feeding the antenna with a balanced open-wire line. (46) 0-4

Among the rhombic variations are the single wire and the nested type where a smaller rhombic is placed inside a larger one to save land area. (46) 10-4

Rhombic antenna type	Range km (mi)	Side length meter (ft)	Tilt angle (deg)	Height meters (ft)	Length, end pole to end pole meters (ft)	Width, side pole to side pole meters (ft)
A	Over 4800 (3,000)	115 (375)	70.0	19.8 (65)	220 (723)	82 (268)
B	3200 (2,000) to 4800 (3,000)	107 (350)	70.0	18.3 (60)	206 (676)	77 (253)
C	2400 (1,500) to 3200 (2,000)	96 (315)	70.0	17.4 (57)	186 (611)	69 (228)
D	1600 (1,000) to 2400 (1,500)	88 (290)	67.5	16.8 (55)	169 (553)	71 (234)
E	960 (600) to 1600 (1,000)	82 (270)	65.0	16.2 (53)	154 (506)	73 (240)
F	640 (400) to 960 (600)	75 (245)	62.5	15.6 (51)	138 (453)	72.5 (238)
G	320 (200) to 640 (400)	68 (225)	60.0	15.2 (50)	124 (407)	72 (236)

TABLE HF-9. DIMENSIONS OF STANDARD COMPROMISE HORIZONTAL RHOMBICS.
(87) 11-4

systems 6. Rhombic Antennas

Reference

Since most rhombic antennas are designed for specific circuits, no manufacturer's manuals are available. Drawings and technical data are available on many rhombic antennas from the Naval Electronic Systems Command.

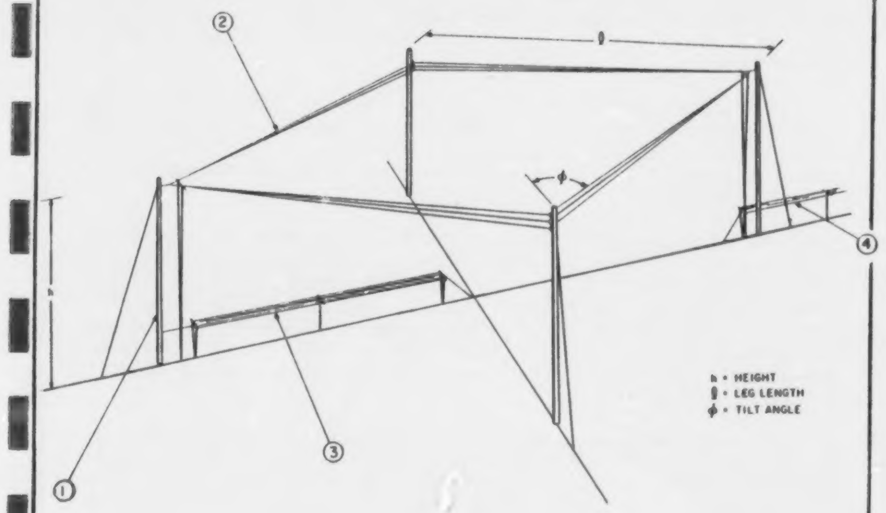


FIGURE HF-29. TRANSMITTING RHOMBIC ANTENNA.

systems 7. Special Rhombic Configurations

Other rhombic configurations shown are used less commonly than the three-wire standard type, but are very efficient for certain applications (Figure HF-30). (68) 4-52

Tiered rhombic--The tiered rhombic consists of two rhombics arranged in a double tier and driven in parallel. This configuration reduces the characteristic impedance of the array, so that the current in the conductors near the input terminals is decreased. High-angle lobes in the vertical plane also are reduced. This antenna has only 1 to 2 decibels higher gain than the single rhombic, but the much improved vertical pattern is less vulnerable to the effects of multipath propagation and noise arriving from high vertical angles. (68) 4-52

Interlaced rhombic--The radiating legs of this system are oriented so that destructive wave interference occurs in almost all directions except along the main beam axis. Such an arrangement (Figure HF-30) can produce a gain 4 to 5 decibels better than the single rhombic antenna without affecting the major lobe's beamwidth. (68) 4-52

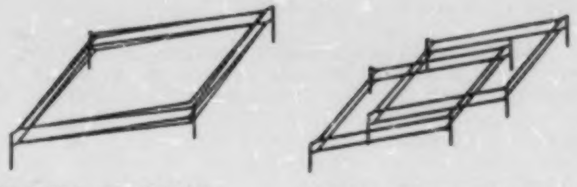
La Port rhombic--This variation of interlacing involves driving two or more rhomboid configurations from a common feed point as shown in Figure HF-30C so that gain is increased through horizontal beamwidth reduction. Such an antenna will have a power gain of approximately 29 decibels with respect to an isotropic antenna. (68) 4-52

Sloping rhombic--When a rhombic antenna is sloped along its axis so that one apex is nearer the ground than the other, the vertical radiation pattern is altered by the change in relationship between the free-space field and the ground-reflected components. The free-space vertical angle increases, with a corresponding decrease or increase in the reflection angle, depending on whether the slope is up or down in the direction of the main beam. The end effect of sloping the antenna is a broadening of the vertical pattern and a slower change rate for the vertical angle of maximum radiation with changing frequency. (68) 4-52

Rhombic antennas can be characterized as high-power, low-angle, high-gain, horizontally polarized, highly directive, broadband antennas of simple, inexpensive construction. A properly designed rhombic antenna presents an input impedance to the transmission line that is insensitive to frequency variations up to 5:1, and it maintains a power gain above 9 decibels anywhere within a 2:1 frequency variation. At the design-center frequency, a power gain of 17 decibels is typical. (68) 4-54

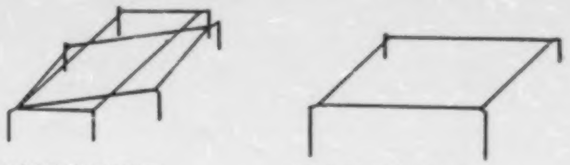
The radiation pattern produced by the four radiating legs of a rhombic antenna is modified by reflections from the earth under and immediately in front of the antenna. Because of the importance of these ground reflections in the proper formation of the main lobe, the rhombic antenna should be installed over reasonably smooth, level ground. The main disadvantage of the rhombic antenna is the requirement for a large land area. (68) 4-54

systems 7. Special Rhombic Configurations



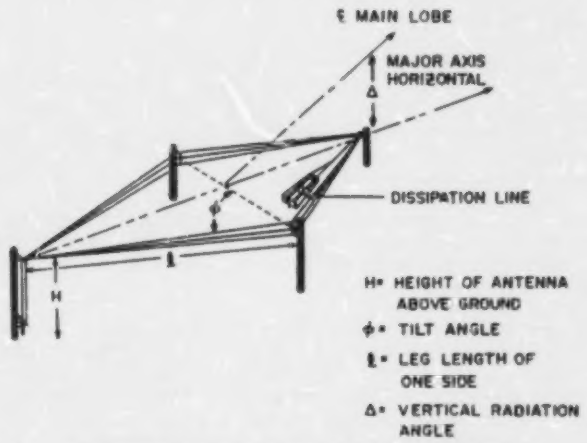
(A) DOUBLE-TIER RHOMBIC

(B) INTERLACED RHOMBIC, DOUBLE-TIER



(C) LA PORT RHOMBIC

(D) SLOPING RHOMBIC


℄ MAIN LOBE
MAJOR AXIS HORIZONTAL
Δ
DISSIPATION LINE
φ
ℓ
H
H= HEIGHT OF ANTENNA ABOVE GROUND
φ= TILT ANGLE
ℓ= LEG LENGTH OF ONE SIDE
Δ= VERTICAL RADIATION ANGLE

(E) NONRESONANT HORIZONTAL THREE-WIRE RHOMBIC

FIGURE HF-30. SPECIAL RHOMBIC ANTENNA CONFIGURATIONS.

systems 8. Short Range HTOA Wide Band Antennas

Antenna description: Nondirectional LPA

Antennas AS-2855/FRC and AS-2856/FRC and their commercial equivalents, TCI 530-3-03 and TCI 530-3-06, respectively, are nondirectional log periodic arrays designed for short-range, sky-wave communications within the 2 to 30 megahertz frequency range. They are horizontally polarized and do not require a ground screen. (46) 14-3

The AS-2855/FRC is designed for medium-power transmission and is identical to the receiving model (AS-2856/FRC), except for its balun and transmission line termination (Figure HF-31). (46) 14-3

The antenna consists of a single guyed tower (1 in Figure HF-31) 133 feet high, which supports four vertical panels of log periodic dipole elements (2). The elements are fed through a two-wire transmission line (3) extending up the tower from a matching balun (4) near the tower base. The four vertical panels of elements are arranged and connected so as to form two log periodic arrays perpendicular to each other. The apex of each panel points directly downward. Consequently, radiation is directed toward the earth and is reflected upward. (46) 14-3

The way in which radiating elements are connected to the feedline shifts their relative phase; as a result, polarization in the horizontal plane is essentially circular. The polarization sense is established during manufacture and cannot be changed in the field. (46) 14-3

The log periodic panel elements are made of Alumoweld conductors and ceramic insulators (5). The longest element of each of the four panels acts also as an insulated top guy for the tower. They are connected to the transmission line with wire jumpers. The other elements of each panel are supported on one end where they connect directly to the feedline, and on the insulated end where they attach to a catenary (6) forming the lower edge of each panel. (46) 4-3

The log periodic panels have a direct static drain path to ground through a shorted-stub line. This line connects to the upper end of the feed line and terminates at a bracket bolted to the tower leg at the 77-foot level. Spark gaps are provided at the matching balun's balanced terminals to protect its windings from failure due to lightning transients. (46) 14-3

The balun of the receiving antenna is relatively small and has a type LC connector for use with a solid dielectric line. Its terminals connect to the antenna feedline through a simple strap and wire arrangement. (46) 14-3

systems 8. Short Range HTOA Wide Band Antennas

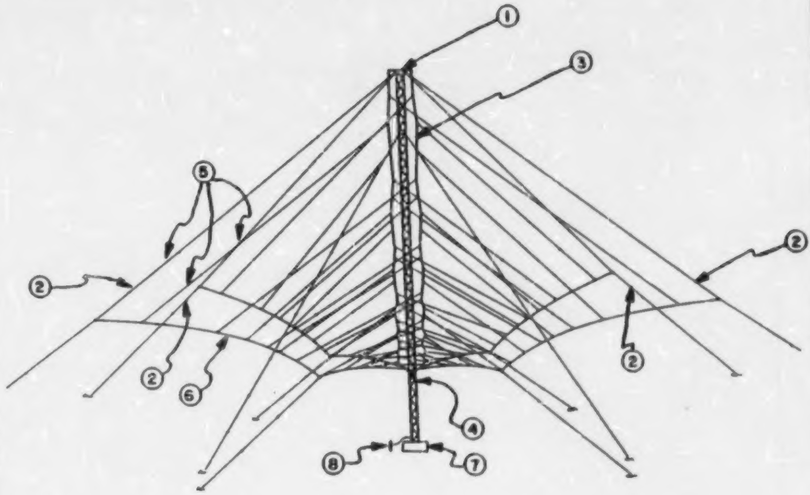


FIGURE HF-31. AS-2855/FRC AND AS-2856/FRC ANTENNA CONFIGURATION.

systems 9. Hermes Loop Array

Antenna description: Hermes loop array

The Hermes loop array 4R/8E13 is an arrangement of 32 loop antennas that serve as eight separate directional receiving antennas with a combined 360-degree coverage in overlapping sectors. The array is vertically polarized, and is intended for high-angle, short- to medium-haul skywave communications in the 2 to 32 megahertz range. Each loop antenna contains a solid-state preamplifier. The array includes power supplies and multicouplers, which are normally located in the receiving equipment building. (46) 15-3

The array consists of four rows of loop/preamplifier elements in a radial configuration or "rosette," with the rows arranged at 45-degree angles to one another. The array occupies a circular area of flat ground less than 100 feet in diameter. Each row consists of eight identical loop/preamplifier elements spaced 13 feet apart (Figures HF-32 and HF-33). They are supported approximately 3 feet above ground on posts or tripods (1 in Figure HF-33), and are connected together by rigid coaxial line (2). The loop/preamplifier elements on the ends of each row are equipped with termination units that have type "N" fittings (3) for connecting the RF feeder cables from the receiver equipment building. (46) 15-3

Each row of eight loop/preamplifier elements serves as two independent directional antennas receiving from opposite directions, although they share the same loop/preamplifier elements and interconnecting transmission lines. Each row is physically and electrically independent of the other rows in the array. (46) 15-3

Four receiver outlets are normally provided in each of the eight 45-degree sectors through multicouplers, which are part of the antenna array. At some stations, more outlets may be made available for some sectors through additional multicouplers. (46) 15-3

A loop element consists of two tubular aluminum hoops, 1 meter in diameter (5), welded to and supported by a vertical hollow aluminum tube (6). The lower part of the vertical support tube contains the preamplifier (7) and includes two flange-type coaxial line connectors (4) and a flange for mounting to a tripod or to a postsupport bracket (8). One of the coaxial line flanges has a red band painted on it to indicate the RF signal output polarity. A removable plug (9) at the bottom of the support tube provides access to the preamplifier for testing as well as for removal and replacement. (46) 15-3

For more information, see the Technical Manual for Aperiodic Loop Antenna Arrays, Hermes, Revision of November 1973 or later.

systems 9. Hermes Loop Array

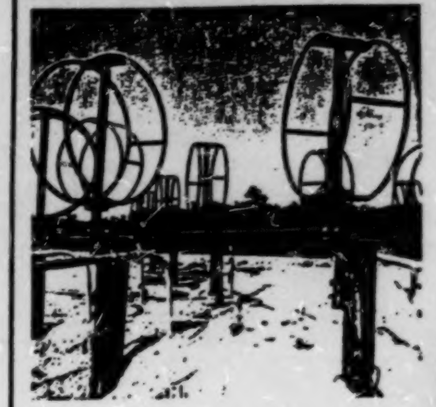


FIGURE HF-32. HERMES LOOP ARRAY 4R/8E13. GENERAL VIEWS.

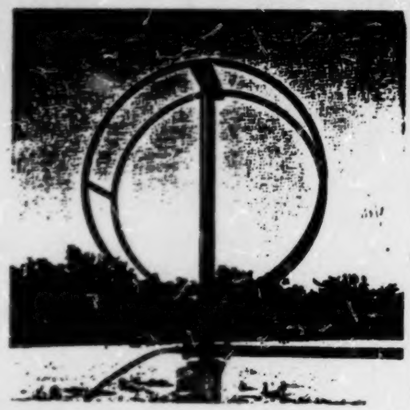


FIGURE HF-32. (CONT'D).

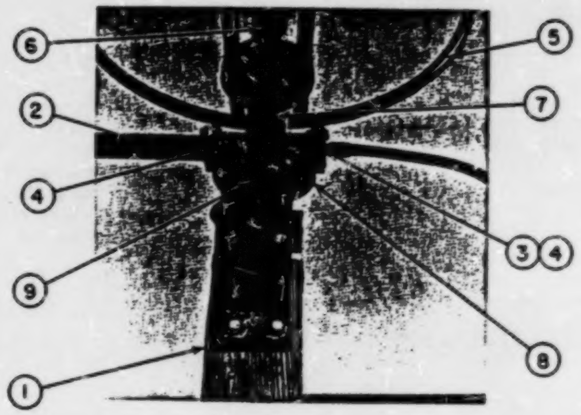


FIGURE HF-33. DETAIL SHOWING EXTENSION TUBE FITTINGS, SEALING PLUG, ETC., FOR HERMES LOOP ARRAY.

systems 10. Half-Wave Antenna(Dipole/Doublet)

Antenna description: Half-wave resonant

The basic half-wave resonant antenna, called either a dipole or doublet, is one of the simplest, most fundamental radiating systems in common use. Geometrically, this antenna is a simple linear element that has an electrical length of one-half wavelength. Normally, the radiator is a thin wire, but larger conductors are sometimes used for antenna applications that require slightly wider bandwidth or lower input impedance than that of a thin wire. (68) 4-1

The two- and three-wire folded dipole versions of the half-wave antenna (Figure HF-34) normally are used for Navy communications service because they can handle greater power and increased bandwidth. NAVSHIPS Drawings ReF2691939, 2691941, 2691942, 2691950, 2691953, 2691956 and 2691982 (formerly BUSHIPS Drawings RE 66F 2034, 2036, 2037, 2045, 2048, 2051 and 2077, respectively) are standard plans for these antennas. (68) 4-1

Assuming the optimal configuration for a given application, the general group of horizontal half-wave antennas can be considered as medium-power, narrow-band, low-gain, and moderately directive radiators of very simple, inexpensive construction.

systems 10. Half-Wave Antenna(Dipole/Doublet)

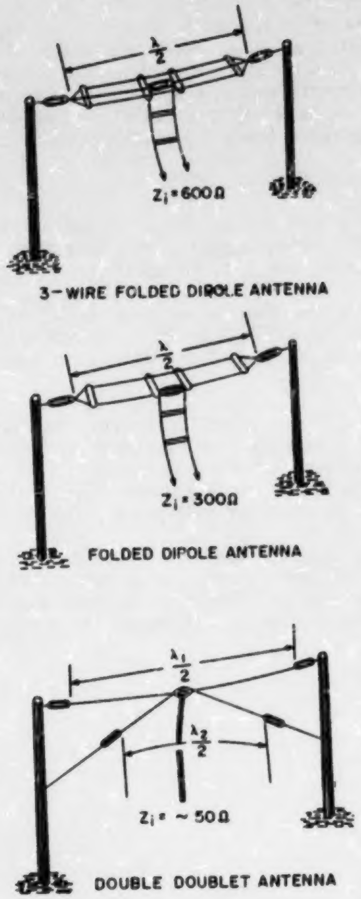


FIGURE HF-34. DIPOLE AND DOUBLET ANTENNAS.

systems 11. Yagi Antenna

Antenna description: Yagi

The Yagi antenna is an end-fire parasitic array. It is constructed of parallel and coplanar dipole elements arranged along a line perpendicular to the dipoles' axes (Figure HF-35). Only one dipole element is driven; the others are parasitic elements coupled to the driven element through currents induced by the driven element's field. (68) 4-4

The radiation pattern, gain, lobe alignment, and front-to-back ratio of a Yagi varies with array height above ground and the number, length, spacing, and radius of the elements. A typical Yagi array, designed either for optimal gain or for a particular front-to-back ratio, operates at a power gain that ranges from 6 to 19 decibels. Generally, yagi antennas develop only one major horizontal-plane minor lobe--the back lobe. Other minor lobes usually can be suppressed more than 20 decibels.

It is difficult to achieve very low vertical radiation angles at the low end of the HF band because the antenna height required becomes too great; for example, for a vertical radiation angle of 5 degrees, the array height must be 2.75 wavelengths. Because of this height requirement, the designer should first consider other antenna types for vertical radiation angles in the 5- to 10-degree range when the operating frequency is lower than 15 megahertz. (68) 4-5

The Yagi antenna is a narrow-band, medium-power, high-gain, highly directive radiator of medium-to-high radiation angle, compact size, and low cost. A typical Yagi array designed either for optimal gain or for a particular front-to-back ratio presents an impedance to the transmission line ranging from 10 to 60 ohms, and operates at a power gain that ranges from 6 to 19 decibels, depending on the array's characteristics. Power handling ability is limited by the feedline, insulators, impedance matching device capacity, and corona at the ends of the elements. (68) 4-7

systems 11. Yagi Antenna

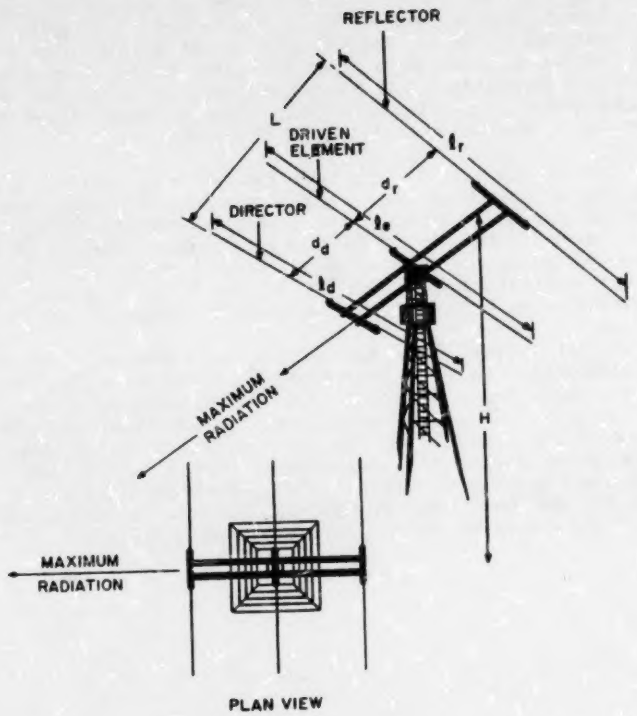


FIGURE HF-35. YAGI ANTENNA.

systems 12.Sector Log-Periodic Array

Antenna description: Sector LPA

This version of a vertically polarized fixed-azimuth LPA consists of four separate antenna curtains supported by a common central tower (Figure HF-36). Each of the four curtains operates independently, providing antennas for a minimum of four transmit or receive systems and a choice of sector coverage. The four curtains also can radiate a rosette pattern of overlapping sectors for full coverage in azimuth, as shown by the radiation pattern in Figure HF-36. The central supporting tower is constructed of steel and may be up to 250 feet high. Each curtain can be up to 250 feet long, according to the frequency range. (68) 4-17

Land requirements for the antenna, including its ground plane (not used in all sector LPAs), usually is approximately 4 to 6 acres for a sector LPA covering the full HF spectrum. (68) 4-17

This type of LPA can handle as much as 20 kilowatts average power with a VSWR no greater than 2:1. A gain greater than 11 decibels with respect to isotropic conditions is possible. (68) 4-17

In general, the LPA is a medium-power, high-gain, moderately directive radiating antenna of extremely broad bandwidth. Bandwidths up to 15:1 are possible with up to 15 decibels power gain. The vertical radiation angle remains relatively constant over the antenna bandwidth on fixed-azimuth LPAs. (68) 4-19

LPAs are rather complex antenna systems and are relatively expensive. LPA installation normally is more difficult than for other HF antennas because of the tower heights and the complexity involved in suspending radiating elements and feedlines from the towers. (68) 4-19

systems 12.Sector Log-Periodic Array

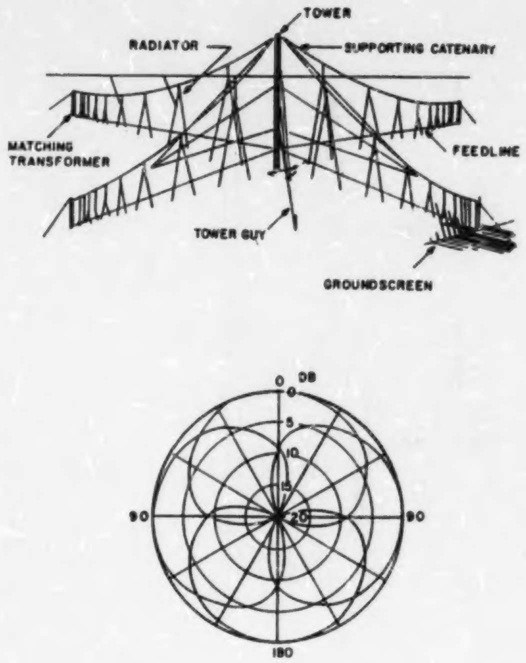


FIGURE HF-36. SECTOR LPA AND HORIZONTAL RADIATION PATTERN.

systems 13. Whip Antennas

Antenna description: Whip

HF whip antennas are vertically polarized omnidirectional monopoles that, electrically, represent the general class of vertical radiators. They are used in short-range ship/shore/ship communications, in transportable communications systems, and in laboratory and shop installations. (68) 4-19

Whip antennas used in HF communications are made of tubular metal or fiberglass-covered metal. They are usually 35 feet long; however, some models are adjustable from a length of 12 feet to a maximum of 35 feet. (68) 4-19

Whips are the least efficient of all the common vertically polarized antennas. Their wide application in Navy HF communications mainly results from their low cost and simple installation. Even though it is generally assumed that HF whips are designed for efficient operation throughout the 2- to 30-megahertz range, actual radiation efficiency largely depends on their operation with associated tuning devices (normally used with transmitters) and a ground plane. Without an antenna tuning system, whips usually have a narrow bandwidth and limited power radiating ability. (68) 4-19

Power ratings of most HF whips range from 1 to 5 kilowatts (PEP), but, in some cases, stainless steel models are used for power ratings above 5 kilowatts. (68) 4-19

Whips do not have unusual siting or installation problems because they can be readily located on poles or platforms, on the tops or sides of buildings, or on transportable units. Installation instructions provided with the antennas do not always take into consideration proper antenna location or ground plane requirements. However, a ground plane consisting of 15 equally spaced radials 25 feet long is usually adequate. (68) 4-19

Two models often used in HF shore communications are the AT-1022/SR and the NT 66047. Both antennas meet Navy requirements and are available through normal procurement channels. (68) 4-19

Although whips are not considered highly efficient and are unsuitable for many purposes, they provide a compromise for receiving and low-to-medium power transmitting installations. Because whips are inexpensive and are easily installed, they are particularly advantageous when time, cost, and space are critical factors. The spacing required between tuned whips is not critical if they are operated at different enough frequencies. (68) 4-20

Antenna description: Sleeve

The HF sleeve antenna is used mainly as a receiving antenna in Navy communications. In its basic configuration, the sleeve is broadbanded, vertically polarized, and omnidirectional. Consequently, its main uses are in broadcast, ship/shore/ship, and ground/air/ground service rather than point-to-point communications. BUSHIPS Drawing RE 66F 2073, Rev. K., and 2075, Rev. G. are the standard plans for transmitting and receiving sleeves, respectively. (68) 4-20. Navy HF communications use several variations of the basic omnidirectional sleeve antenna. (68) 4-20

The sleeve antenna shown in Figure HF-37 consists of two sections: a grounded lower base and an upper ungrounded part. The upper section is longer and smaller in diameter than the lower section. The upper section is constructed of multiple vertical wires supported by a wood pole. The wires are joined at the lower and upper ends, and are spaced to a maximal width at the center. The spacing of the upper-section conductors is varied in a way that reduces antenna capacitance at the feedpoint. The lower section is a wooden structure with 10 parallel wires distributed from top to bottom on each side. The transmission line is connected through a transformer to the junction of the base and upper section. The sleeve antenna's nominal impedance is 50 ohms. Maximal transmitter power handling ability generally is limited to 10 kilowatts (PEP) because of limiting factors imposed by the impedance matching device. (68) 4-20

The basic omnidirectional sleeve antenna provides a gain of approximately 2 decibels over a frequency range of 3:1, presenting a VSWR of 3:1 or less over the frequency range. (68) 4-20

The sleeve antenna is installed above a ground radial system consisting of 120 wires spaced 3 degrees apart and at least one-quarter wavelength long at the lowest design frequency. (68) 4-20

The radial wires are connected to the lower grounded section and are electrically common with the lower section. Because a ground plane is required, a sleeve antenna will occupy 2 to 4 acres of land. (68) 4-20

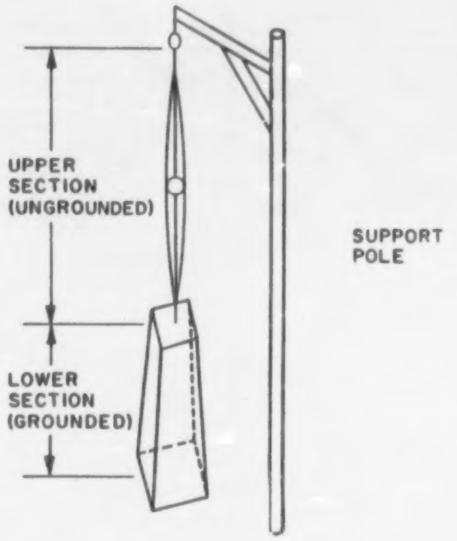


FIGURE HF-37. SLEEVE ANTENNA.

180-degree sector sleeve--Figure HF-38 shows this variation of the basic sleeve. The upper and lower sections in the 180-degree sector sleeve are the same as in the basic antenna; addition of a director and a reflector provides the directivity. This type of sleeve operates effectively over a frequency range of 3:1 with a VSWR of 3:1, and provides a gain approximately 3 decibels higher than that of the omnidirectional version. Typical frequency ranges for the 180-degree sector sleeve are 4 to 12 megahertz, and 9 to 27 megahertz. BUSHIPS Drawings RE 66F 2115, Rev. A, and 2116, Rev. A are the standard plans for the 180-degree transmitting and receiving sleeves, respectively. (68) 4-20

The director is mainly intended to prevent the beam from becoming too broad and splitting at the high end of the frequency range. The director is usually constructed in cylinder form, consisting of six wires of the type and size of the antenna element. (68) 4-21

The reflector consists of 20 vertical wires, 0.1 inch or larger in diameter, connected to the ground plane. (68) 4-21

The ground plane required for the 180-degree sector sleeve is similar to that for the basic sleeve antenna except that the radial wires distributed in the reflector's direction do not extend beyond the reflector. They are terminated at the lower end of the reflector and are made electrically common with the reflector wires. (68) 4-21

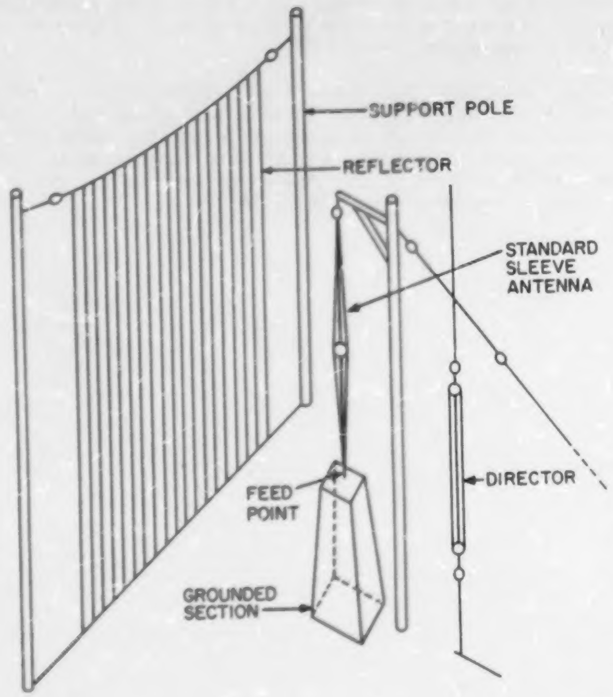
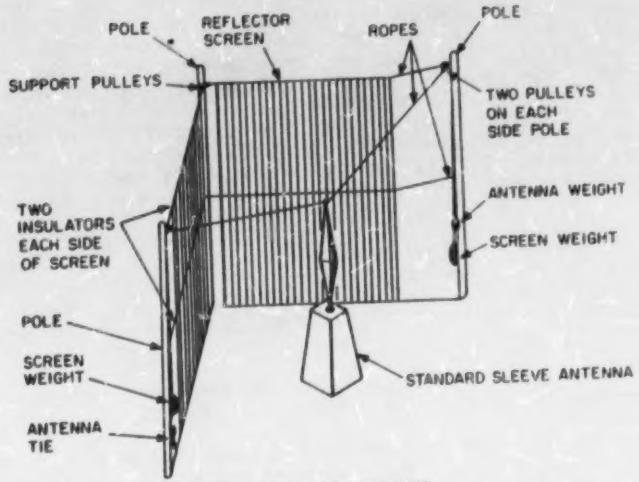


FIGURE HF-38. 180-DEGREE SECTOR SLEEVE ANTENNA.

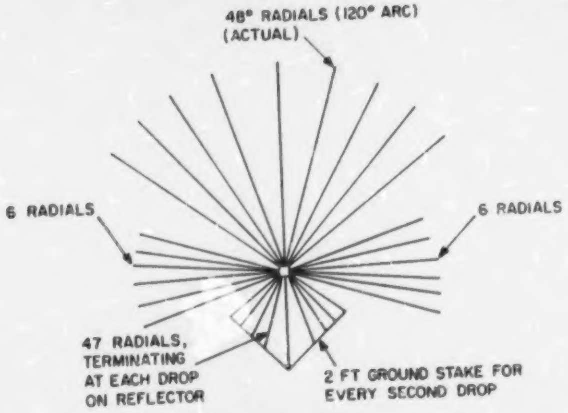
90-degree corner reflector--Figure HF-39 shows the corner reflector variation of the basic sleeve antenna. Physical differences of this sleeve antenna and the basic omnidirectional and 180-degree sector sleeve are readily apparent by comparing Figures HF-35 through HF-37. (68) 4-22

The 90-degree corner reflector configuration provides a gain of approximately 5 decibels over the omnidirectional sleeve. Other electrical characteristics, with the exception of beamwidth and directivity, are essentially the same as the omnidirectional and 180-degree sector sleeves. A system of extended ground radials is required for the corner reflector configuration to achieve the gain and front-to-back ratio desired. Generally, these radials are 2.5 wavelengths long at the lowest design frequency. Figure HF-39 also shows this ground plane. (68) 4-22

Sleeve antennas are classified as relatively low-power, broadband, lower-angle radiators of moderately low cost. The basic omnidirectional sleeve has electrical properties very similar to those of the conical monopole and discone type antennas. Because they can handle only relatively low power levels, sleeves are used mainly as receiving antennas. (68) 4-24


POLE
REFLECTOR SCREEN
ROPES
POLE
SUPPORT PULLEYS
TWO PULLEYS ON EACH SIDE POLE
ANTENNA WEIGHT
TWO INSULATORS EACH SIDE OF SCREEN
SCREEN WEIGHT
POLE
STANDARD SLEEVE ANTENNA
SCREEN WEIGHT
ANTENNA TIE

90° CORNER REFLECTOR ANTENNA


48° RADIALS (120° ARC) (ACTUAL)
6 RADIALS
6 RADIALS
47 RADIALS, TERMINATING AT EACH DROP ON REFLECTOR
2 FT GROUND STAKE FOR EVERY SECOND DROP

GROUND SYSTEM

FIGURE HF-39. 90-DEGREE CORNER REFLECTOR SLEEVE ANTENNA AND GROUND SYSTEM.

Antenna description: Discone

Discone antennas are vertically polarized omnidirectional radiators that have an exceptionally uniform impedance over a wide frequency range. These antennas may or may not be installed with ground radials in the earth. When ground radials are not used, disk radials located above the antenna serve the ground plane function. The type of discone shown in Figure HF-40 is an elevated discone that uses disk radials located above the upper conic surface. (68) 4-24

Geometrically, the discone antenna is an upright truncated cone topped with a circular disk that is perpendicular to and symmetrical about the axis of the cone. For HF communications, the conic surface is formed of properly spaced wires, and the disk is usually formed of radially spaced self-supporting tubing. The coaxial transmission line is connected between the top base of the truncated cone and the center of the horizontal disc. At the lower end of the HF band, the top disk becomes excessively large and clumsy; therefore, it is common to invert the discone configuration for frequencies below approximately 10 megahertz. (68) 4-24

The discone antenna's maximal power handling ability is limited primarily by the conic and disk section spacing and by the coaxial transmission line size. (68) 4-27

The antenna's shape and size are designed specifically for the required vertical radiation pattern, bandwidth ratio, and input impedance. (68) 4-27. The discone antenna has a maximal gain ranging from 2 to 5.5 decibels above isotropic level. At frequencies more than three octaves above the cutoff frequency, the vertical beamwidth is 50 degrees or more and the vertical radiation pattern has high-angle multiple lobes with a large amplitude. (68) 4-27

HF discones are generally classed as medium-power, broadband, omnidirectional, relatively expensive antennas. Their use in Navy communications is rather limited since both the inverted cone and conical monopole are better suited to the Navy's shore communications needs. (68) 4-27

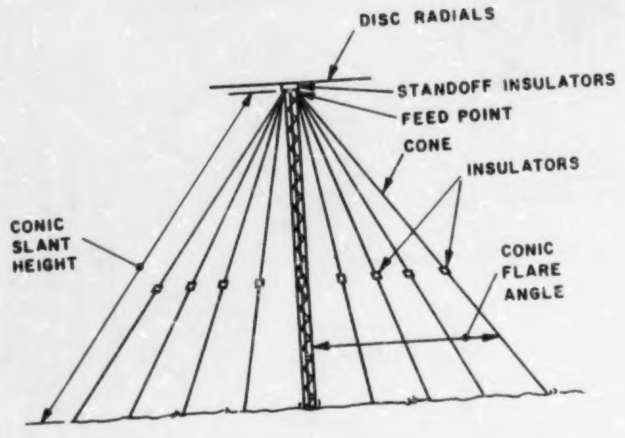


FIGURE HF-40. ELEVATED DISCONE ANTENNA.

Antenna description: Selectively directional monopole

The selectively directional monopole system is a complex, high-power, broadband vertically polarized HF transmitting antenna that provides either omnidirectional or selected directional radiation as desired. Five to eight acres of land are required for siting. These antennas are expensive compared with other HF vertical radiators. (68) 4-37

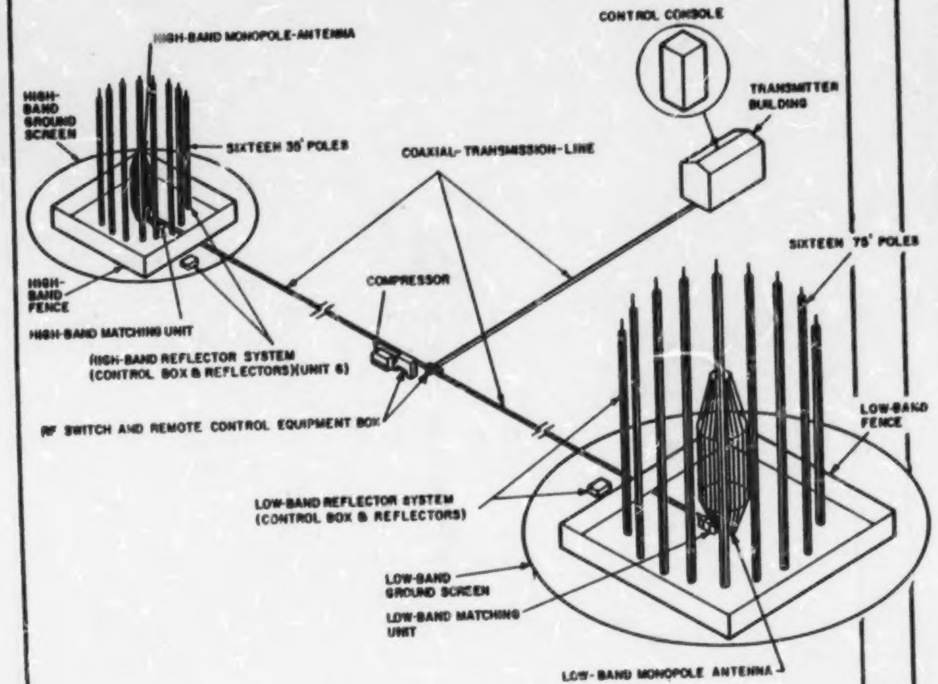

HIGH-BAND MONOPOLE-ANTENNA
HIGH-BAND GROUND SCREEN
SIXTEEN 35' POLES
HIGH-BAND FENCE
HIGH-BAND MATCHING UNIT
HIGH-BAND REFLECTOR SYSTEM (CONTROL BOX & REFLECTORS)(UNIT 6)
RF SWITCH AND REMOTE CONTROL EQUIPMENT BOX
COAXIAL-TRANSMISSION-LINE
COMPRESSOR
CONTROL CONSOLE
TRANSMITTER BUILDING
SIXTEEN 75' POLES
LOW-BAND FENCE
LOW-BAND REFLECTOR SYSTEM (CONTROL BOX & REFLECTORS)
LOW-BAND GROUND SCREEN
LOW-BAND MATCHING UNIT
LOW-BAND MONOPOLE ANTENNA

FIGURE HF-41. ANTENNA SET--AN/FRA-109.

The latest model of this antenna has been accepted and placed in service for Navy HF transmitting. Called the "AN/FRA-109," this antenna is a high-power radiator that can operate either omnidirectionally or directionally. (68) 4-34

The AN/FRA-109 antenna system consists of two separate monopole antennas plus auxiliary equipment (Figure HF-41). (68) 4-34 One monopole (low band) covers the 4- to 11-megahertz range; the other (high-band) covers the 11- to 30-megahertz range. The two antennas are identical in construction except for differences in physical size dictated by frequency. Figure HF-42 shows the monopole. (68) 4-34

Both monopole antennas are surrounded by 16 equally spaced reflectors that can be activated to direct the transmitted signal into a wide or narrow beam in any of the eight compass bearings (N, NE, E, SE, S, SW, W, NW). A single reflector consists of six lengths of copper tubing mounted end to end and separated by five pneumatic switches. Air pressure from a compressor controls a movable contact within each of the switches. The contact is held open by a spring. When air is introduced into a reflector, the air pressure overcomes the spring tension, and the switch contacts close, thus activating the reflector. By decreasing the air pressure, the switches open and the reflector is deactivated. The reflector control units located in the transmitter building establish the antenna's directional and beam width characteristics by activating groups of reflectors selectively. The beamwidth is established by the number of reflectors activated and the direction of radiation is determined by the physical location of the activated reflectors in relation to the monopole antenna. If all the reflectors are deactivated, the antenna radiates omnidirectionally. The reflector assemblies are mounted on wooden poles attached by standoff insulators (Figure HF-43). The reflectors for both high- and low-band are identical except for length. (68) 4-34

Both monopoles require separate ground plane systems of wire radials. These radials are welded to a perimeter bonding-wire which is connected to ground rods. The diameter of the low-band ground plane configuration is 246 feet; the high-band is 90 feet in diameter. (68) 4-36

The AN/FRA-109 system can handle 300 kilowatts average power over the 4 to 30 megahertz frequency range. (68) 4-37. Directive gain for the system is no less than 4.5 decibels in the omnidirectional mode, and no less than 8.5 and 9.5 decibels in the wide (180 degree) and narrow (45 degree) directive modes, respectively. (68) 4-37

Coaxial transmission lines (50-ohm) feed the monopoles. VSWR is 2:1 or less throughout the design frequency range. (68) 4-37

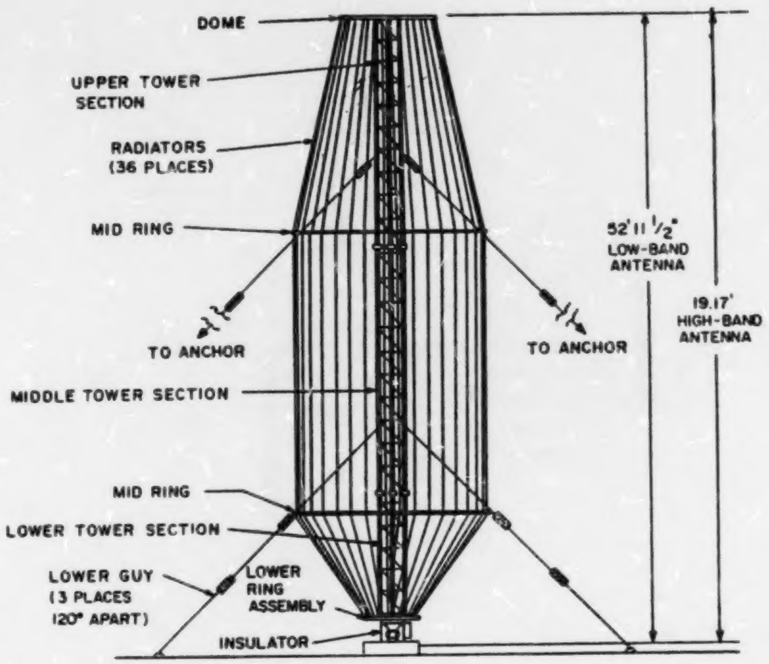

DOME
UPPER TOWER SECTION
RADIATORS (36 PLACES)
MID RING
TO ANCHOR
TO ANCHOR
MIDDLE TOWER SECTION
MID RING
LOWER TOWER SECTION
LOWER GUY (3 PLACES 120° APART)
LOWER RING ASSEMBLY
INSULATOR
52' 11 1/2" LOW-BAND ANTENNA
19.17' HIGH-BAND ANTENNA

FIGURE HF-42. LOW- AND HIGH-BAND MONOPOLE ANTENNA.

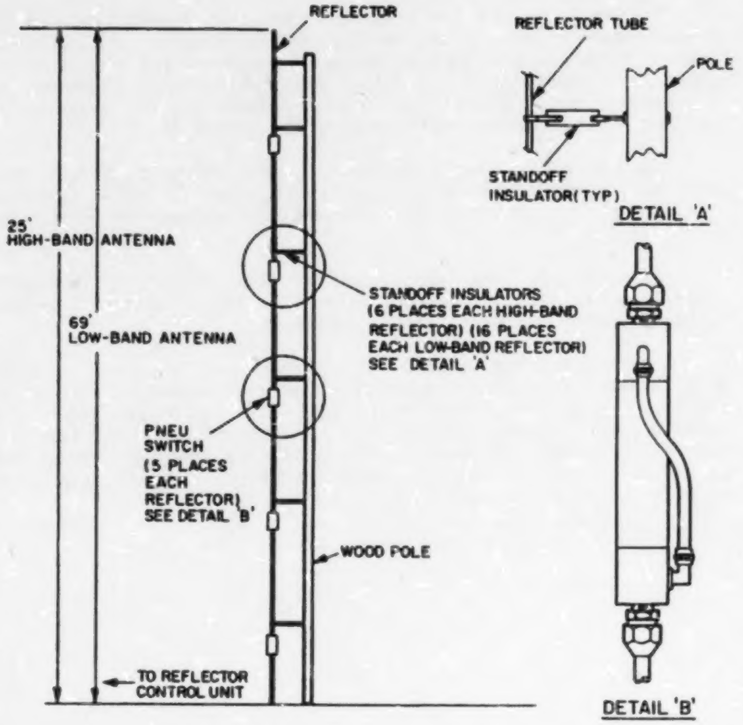

REFLECTOR
25' HIGH-BAND ANTENNA
69' LOW-BAND ANTENNA
STANDOFF INSULATORS (6 PLACES EACH HIGH-BAND REFLECTOR) (16 PLACES EACH LOW-BAND REFLECTOR) SEE DETAIL 'A'
PNEU SWITCH (5 PLACES EACH REFLECTOR) SEE DETAIL 'B'
WOOD POLE
TO REFLECTOR CONTROL UNIT
REFLECTOR TUBE
POLE
STANDOFF INSULATOR(TYP)
DETAIL 'A'
DETAIL 'B'

FIGURE HF-43. INDIVIDUAL LOW- AND HIGH-BAND REFLECTORS.

systems 17. Horizontal Vee Antenna

Antenna description: Horizontal vee

The horizontal vee antenna is a long-wire radiating system with properties very similar to those of the rhombic. (68) 4-54. The vee antenna's two horizontal long-wire radiators are arranged in a "V" shape with the apex of the vee connected to the transmission line. Each wire contributes a field to the resulting bidirectional radiation pattern. To make the system nonresonant and unidirectional, the legs of the vee are terminated with noninductive 400- to 600-ohm resistors as shown in Figure HF-44. (68) 4-54

The vee antenna's radiation efficiency is typically 35 to 50 percent--substantially less than that of the rhombic. The radiation pattern and power gain vary widely with frequency and with physical shape and dimension. The important physical parameters (Figure HF-44) include the height of the radiators above ground, apex angle, leg length, and vertical radiation angle. (68) 4-54

The vee antenna requires approximately one-half as much land area as the rhombic antenna, typically between 3 and 7 acres of level ground. Supporting structure heights range from 50 to 150 feet. (68) 4-54

Although the vee has many of the rhombic's desirable properties, it does not perform as well as the rhombic with regard to maximal gain and directivity. (68) 4-54

A terminated vee antenna is a high-power, low-angle, medium-gain, horizontally polarized, highly directive broadband antenna of simple, inexpensive construction. The directive gain is approximately 3 decibels below that of a rhombic with the same leg length. The vee is moderately insensitive to frequency variations up to 3:1. At the design center frequency, a power gain of 9 decibels is typical. (68) 4-54

systems 17. Horizontal Vee Antenna

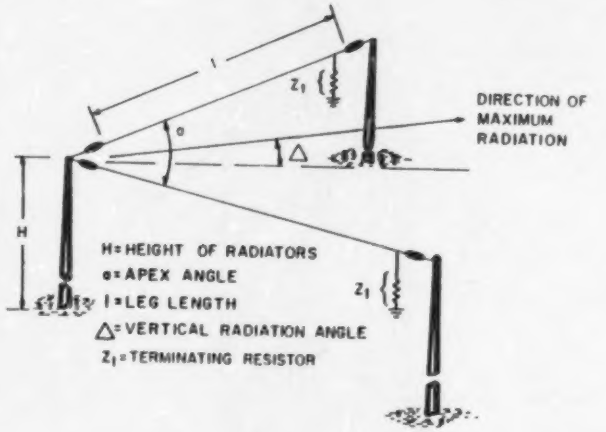


FIGURE HF-44. NONRESONANT HORIZONTAL VEE ANTENNA.

Antenna description: Wullenweber array

The Wullenweber array is an effective vertically polarized antenna used in Navy HF receiving systems. Although its initial development was for HF direction finding, the Wullenweber has also been accepted for service as a point-to-point communications antenna. The Wullenweber can provide omnidirectional coverage, sector coverage of rather broad beamwidth, or highly directive beams separately or simultaneously, as desired. (68) 4-55

A typical Wullenweber array consists of two reflecting screens and two sets of antenna elements arranged in four concentric circles over a ground plane system of radials and mats. The low-band reflector screen forms the innermost circle. Proceeding outward, there is a circle of 40 low-band antenna elements, then the high-band reflector screen, and then the circle of 120 high-band antenna elements. The Wullenweber array diameter is approximately 875 feet (circle diameter of the high-band antenna elements). However, the ground radials extend beyond this distance. (68) 4-55

The Wullenweber array is designed to receive HF signals ranging from 2 to 10 megahertz on the low-band, and from 10 to 30 megahertz on the high-band antenna. (68) 4-56. The low- and high-band reflector screens are composed of vertical wires attached at the upper end to pole-supported horizontal beams, and connected to the ground plane at the lower end. This vertical screen arrangement contributes to the directional characteristics for the Wullenweber array. (68) 4-56

Each low- and high-band antenna element is connected to a buried coaxial transmission line that is terminated in a receiving multicoupler. All transmission lines must be electrically equal in length to insure that the phase delay in each line is the same. Outputs of the multicouplers are fed into passive beam-forming networks and into other multicouplers to combine selected antenna elements, thus forming the desired radiation patterns and directivity. (68) 4-56

In finding more uses for the Wullenweber array, a transportable model, the AN/TRA-40, was developed, and is being used as the primary point-to-point receiving antenna at one naval communications station. (68) 4-56. The AN/TRA-40 is a transportable communications receiving antenna. It operates generally in the same way as the typical Wullenweber array just described. The main differences are that the AN/TRA-40 has only one reflector screen, has fewer elements in both arrays, and is packaged as a transportable system using semitrailer vans. Figure HF-45 shows the main units for this type of Wullenweber antenna. (68) 4-56

The antenna consists of a reflector screen, 36 low-band antenna elements, 72 high-band antenna elements, a ground mat, a beamformer van, and interconnecting RF cables. The vertical circular reflector

screen is 500 feet in diameter, and the high- and low-band elements are located on larger circles concentric to it. A circular ground mat extends outward from the reflector screen and beyond the elements. Buried transmission lines connect the elements to the van at the center of the array where the beamforming occurs. (68) 4-57

The AN/TRA-40 antenna array provides 36 high-gain directional beams, at 10-degree azimuthal increments, in each of two bands which, together, cover the entire 3- to 30-megahertz frequency range. The low band is 3 to 10 megahertz and the high band is 3 to 10 megahertz. The antenna array also provides three 120-degree sector beams and a 360-degree omnidirectional pattern which is effective for the full HF range. (68) 4-57

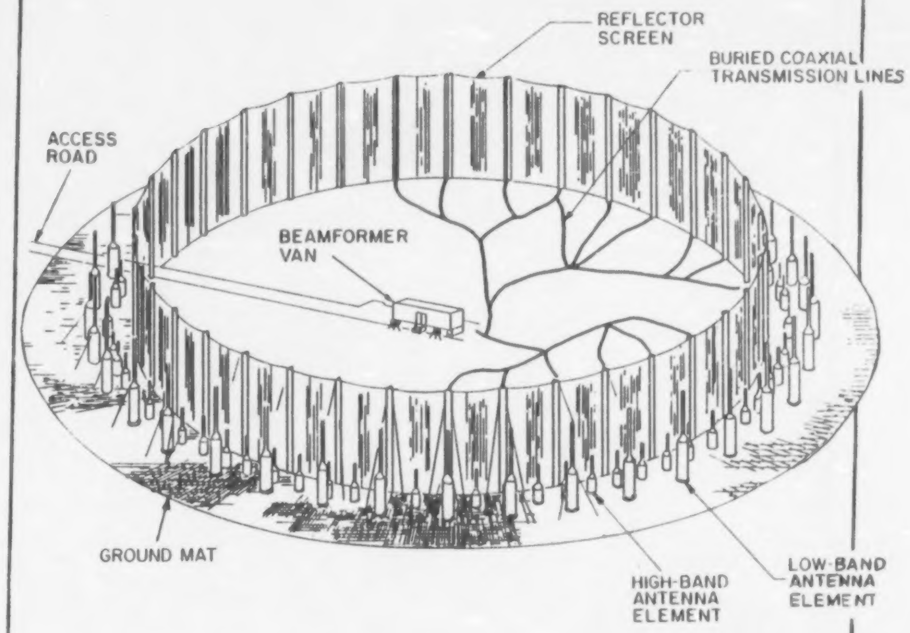


FIGURE HF-45. ANTENNA GROUP AN/TRA-40.

systems 18. Wullenweber Antenna Array

The Wullenweber array is a high-gain (12 to 14 decibels), wideband (typically 8:1 to 10:1), extremely versatile antenna for HF receiving. (68) 4-57. Most Navy receiver sites using the Wullenweber antenna for point-to-point communications do so on a shared basis with other mission requirements. However, one naval communications station has two complete Wullenweber arrays, both of which are dedicated to point-to-point communications. The two arrays, located at NAVRADSTA (R), Sugar Grove, West Virginia, are separated enough that space diversity receiving techniques can be used. (68) 4-57

Compared to a rhombic antenna park designed to provide the same capability, the Wullenweber requires much less land area. However, its complex RF distribution and beamforming networks, plus the extensive site preparation necessary, may require much greater time, effort, and expense than other HF antenna systems. (68) 4-57

systems 19. HF Quadrant Antenna

Antenna description: HF quadrant

The HF quadrant antenna is a system of horizontally polarized dipole antennas used at the ground terminal in ground/air/ground communications receiving. It can be used in polarization diversity with discones, inverted cones, monopoles, or other vertical antennas to improve reception of signals from aircraft. (68) 4-57

Figure HF-46 shows the quadrant antenna's basic configuration. Specific design, construction, and assembly details are available in Bureau of Yards and Docks Drawing 1,046,653, Sheets 1 through 5. (68) 4-57

The quadrant antenna is a set of six separate horizontal dipoles, each of which is bent 90 degrees (Figure HF-46) to produce a somewhat omnidirectional radiation pattern. The overall frequency covered by the set of antennas is 4 to 30 megahertz. (68) 4-57

Each antenna is suspended parallel to the earth's surface at a height of approximately one-half wavelength at its design frequency. Therefore, the height varies from approximately 20 feet for the highest frequency dipole, to about 100 feet for the lowest frequency dipole. (68) 4-60

Although the six antennas share common supporting structures, they are electrically separate and require separate transmission lines. Each antenna set has a balanced input; thus, it is necessary to use separate balun transformers to match each antenna to its transmission line. (68) 4-60

The HF quadrant antenna is a special-purpose receiving antenna used in ground/air/ground communications. It is unique among horizontally polarized antennas because its element arrangement makes possible an azimuthal radiation pattern resembling that of a vertically polarized omnidirectional antenna. Construction and installation of this antenna is complex because of the physical relationships between individual elements and because of the requirement for a separate transmission line for each dipole. (68) 4-60. Approximately 2.2 acres of land are required to accommodate this antenna. (68) 4-60

systems 19. HF Quadrant Antenna

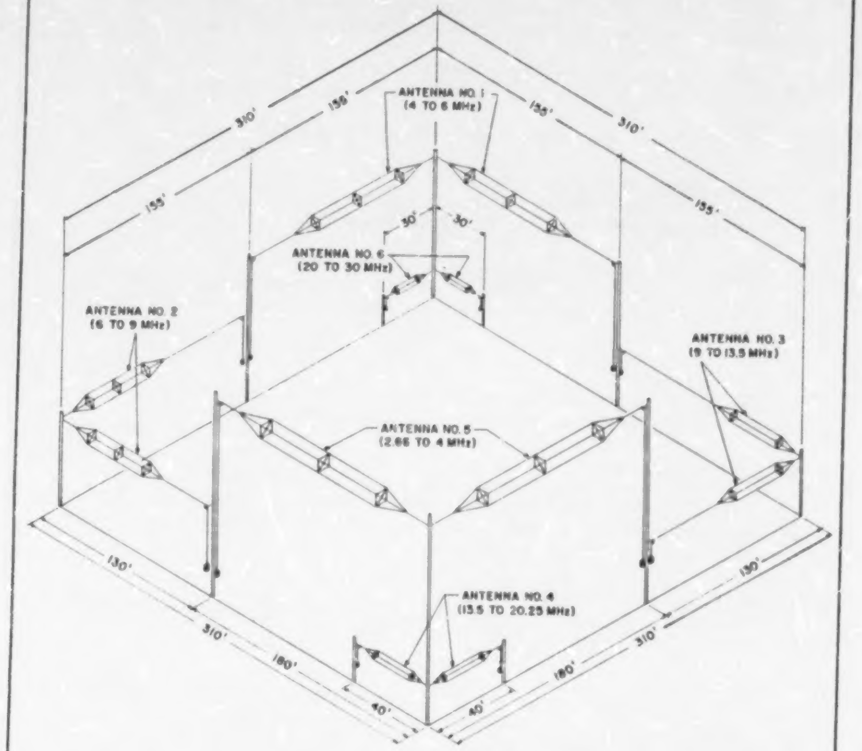
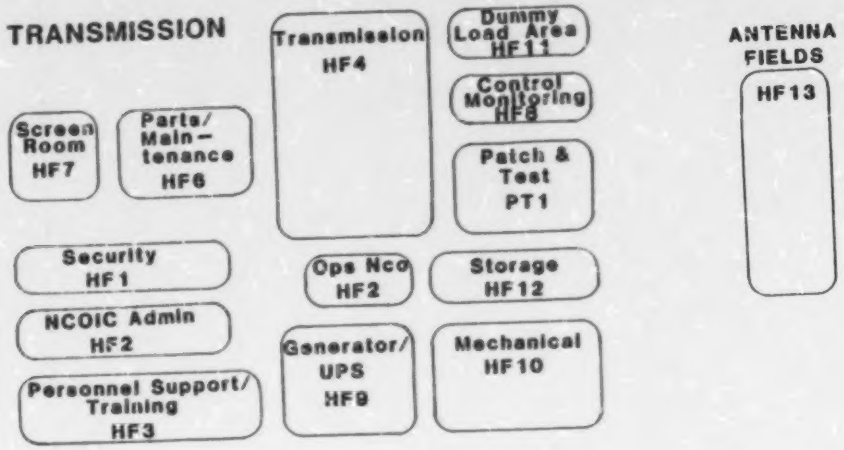

310'
155'
ANTENNA NO. 1
(4 TO 6 MHz)
155'
310'
155'
155'
30'
30'
ANTENNA NO. 6
(20 TO 30 MHz)
ANTENNA NO. 2
(6 TO 9 MHz)
ANTENNA NO. 3
(9 TO 13.5 MHz)
ANTENNA NO. 5
(2.66 TO 4 MHz)
130'
130'
ANTENNA NO. 4
(13.5 TO 20.25 MHz)
310'
180'
310'
180'
40'
40'

FIGURE HF-46. HF QUADRANT ANTENNA.

systems

STANDARDIZED MODULES HF14


TRANSMISSION
Screen Room HF7
Parts/ Main-tenance HF6
Transmission HF4
Dummy Load Area HF11
Control Monitoring HF8
Patch & Test PT1
Security HF1
Ops Nco HF2
Storage HF12
NCOIC Admin HF2
Generator/ UPS HF9
Mechanical HF10
Personnel Support/ Training HF3
ANTENNA FIELDS
HF13

building design principles

1. Efficiency of operational functions
   a. Communication equipment aligned for surveillance and access.
   b. On-the-job training with operating equipment.
   c. Interaction of operational support activities.
   d. Accessibility of toilets for operations personnel.

2. Integration of parts/maintenance modules with operations
   a. Parts/maintenance modules contiguous with operations spaces.
   b. Loading dock accessibility for equipment and supplies.

3. Efficiency and accessibility of administration spaces
   a. Administration transition space between public areas and secure spaces.
   b. Efficiency of integrated administrative spaces.

4. Personnel support spaces
   a. Change of environment for on-duty personnel.
   b. Facilities available for physical training.

5. Integration of power/UPS modules
   a. Economies and efficiencies of integrated power modules.
   b. Minimized impact of generators on communications transmissions.

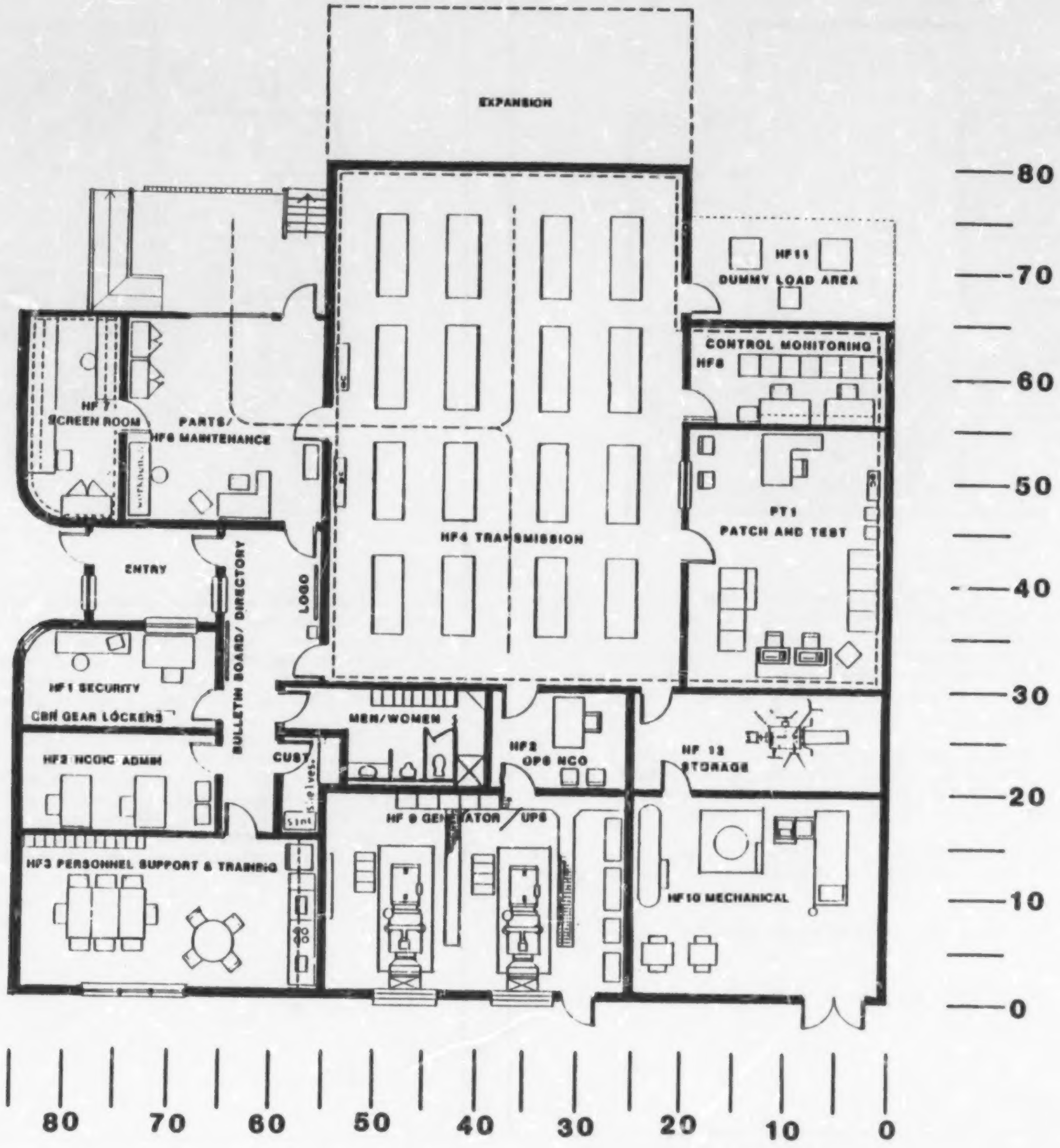
6. Facility expansion
   a. Expansion potential in new construction operations space.
   b. Minimized impact of future operations space expansion.

7. Security operation
   a. Location of security space to control building access.
   b. Central monitoring of total site and building security.
   c. Message security in operations and cryptography modules.
   d. Limited access into secure areas.

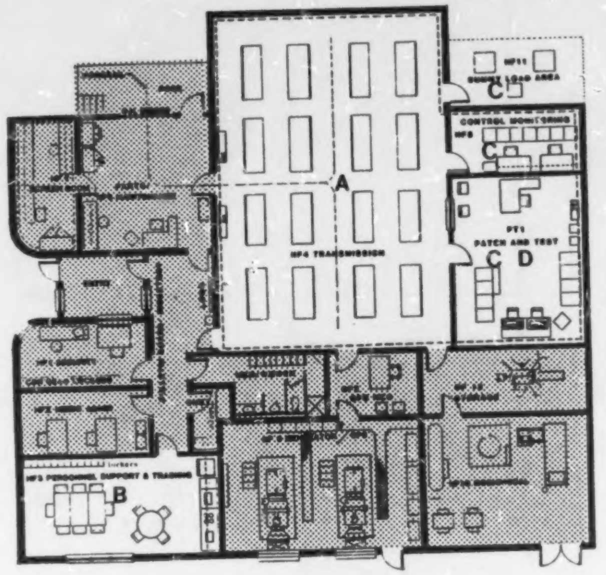
8. Facility security/survivability
   a. Required vault construction for communication system equipment.
   b. Protection of the communication signal.

9. Fire protection
   a. Fire protection classifications: occupancy, hazard of contents, sprinkler protection, and construction/materials.
   b. Building separation distances.
   c. Fire protection systems: automatic fire suppression, automatic notification/alarm, and automatic fire detection.

10. Life Safety
   a. Occupant load determination.
   b. Protected exit conditions: exit capacities, number of exits, exit travel distances, and means of exit arrangement.
   c. Allowable interior finishes.
   d. Egress path identification: illumination of means of egress, emergency lighting, and means of egress marking.


EXPANSION
HF11
DUMMY LOAD AREA
CONTROL MONITORING
HF8
HF7
SCREEN ROOM
PARTS/
HF6 MAINTENANCE
HF4 TRANSMISSION
PT1
PATCH AND TEST
ENTRY
BULLETIN BOARD/ DIRECTORY
LOGO
HF1 SECURITY
CBR GEAR LOCKERS
HF2 NCOIC ADMIN
MEN/WOMEN
CUST
shelves
Sink
HF2
OPS NCO
HF 12
STORAGE
HF3 PERSONNEL SUPPORT & TRAINING
HF 9 GENERATOR / UPS
HF10 MECHANICAL
80
70
60
50
40
30
20
10
0
80
70
60
50
40
30
20
10
0

guidance 1. Efficiency of Operational Functions



A. Equipment should be aligned in parallel rows within the operations modules for ease in visual surveillance and to provide direct access to all critical equipment. Multiple consoles should be adjacent to each other so that limited personnel can monitor them efficiently at one central location. Tables for audiovisual training aids should be available in operations modules so that personnel can train on-the-job during regular watch periods.

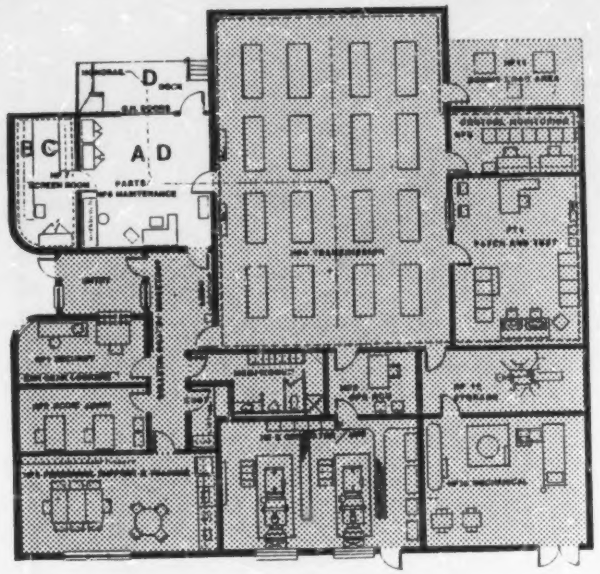
B. To further enhance the effectiveness of on-the-job training, instruction can be done in small groups of four or five in a training room for hands-on experience with communications equipment. This requires a close relationship with the operations module.

C. Additional building modules with a close functional relationship to operations activities should be located adjacent to the operations module.

D. Toilet facilities should be nearby for personnel in the operations module.

E. See technical control module information in section TC, Vol 1B.

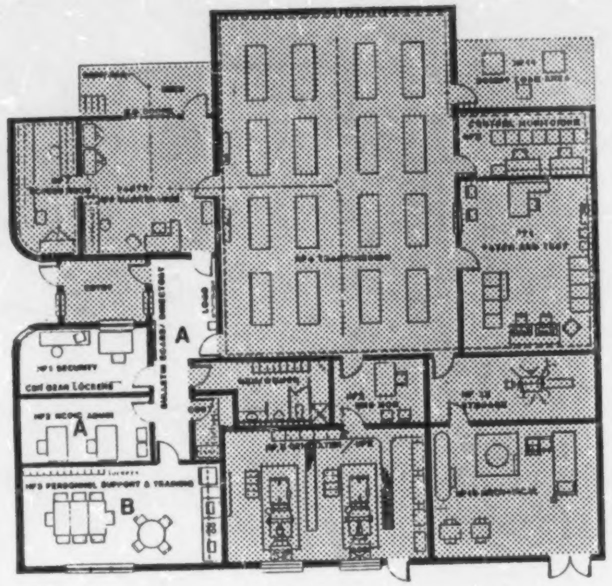
guidance 2. Integration of Parts/Maint. Modules with Ops.



A. Parts and maintenance modules should be well integrated and contiguous with the operations spaces to optimize efficiency and minimize circulation. The secure door between the operations and the maintenance/parts spaces is used only as a fire exit and to bring communication equipment in from and out to the loading dock. This door should have opening hardware only on the secure side.

B. Parts and maintenance from modules must be located within an organizational context such that deliveries can be made to the total building in a direct and secure process at a loading dock. The large communication equipment can be moved in and out more easily using the loading dock. (Also, in multistory communication buildings, an elevator should be located adjacent to the parts module for safe vertical movement of large communication equipment throughout the building.)

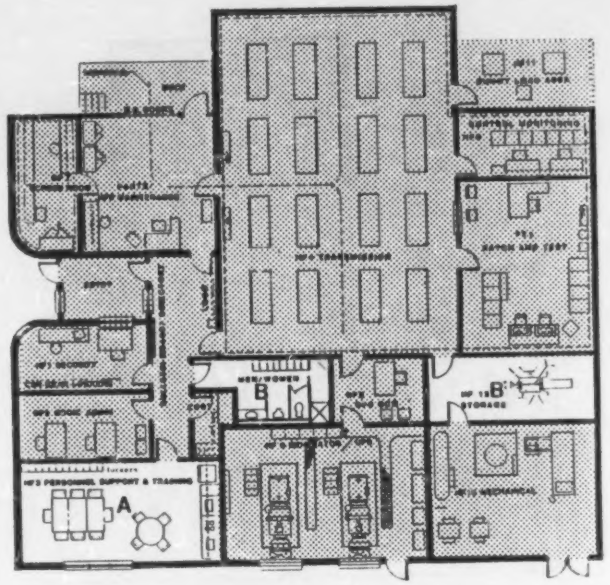
guidance 3. Efficiency and Accessibility of Admin. Spaces



A. Administration modules must be easily accessible to the public to minimize circulation and to prevent visitor interference with facility operations. The administration modules should provide a buffer and transition space between the exterior and interior secure spaces. Also, public corridors in the administration area should contain military unit logos and other display panels that relate to the "esprit de corps" and unit integrity of the communication station.

B. Administration spaces' integrated relationship will improve efficiency by minimizing public and administrative circulation and by producing a group adjacency to shared conference areas, secretaries, and waiting areas.

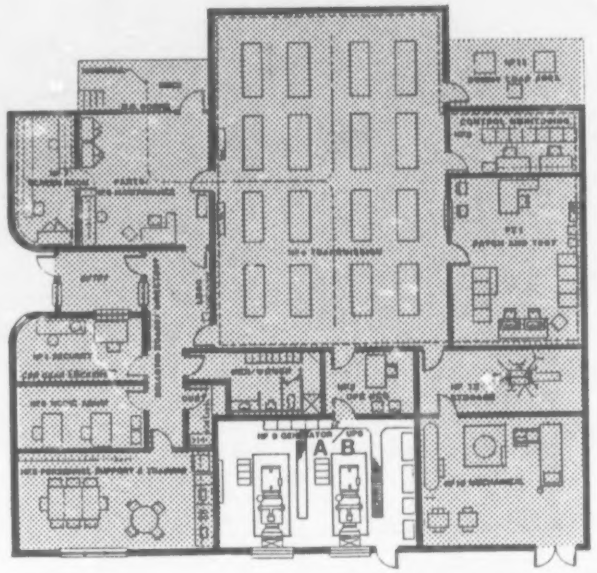
guidance 4. Personnel Support Spaces



A. The intense activities inside the DCS facility tend to generate mental fatigue among personnel. It is therefore necessary to create a change of environment for on-duty personnel to provide a break from the "hard surface" equipment room and work areas. The personnel support module should be directly adjacent to the operations room, but isolated acoustically and visually.

B. In addition, physical exercise equipment is recommended for DCS facilities located off military bases. The necessary showers and lockers should be similarly adjacent to the operations module for easy access and optimal use.

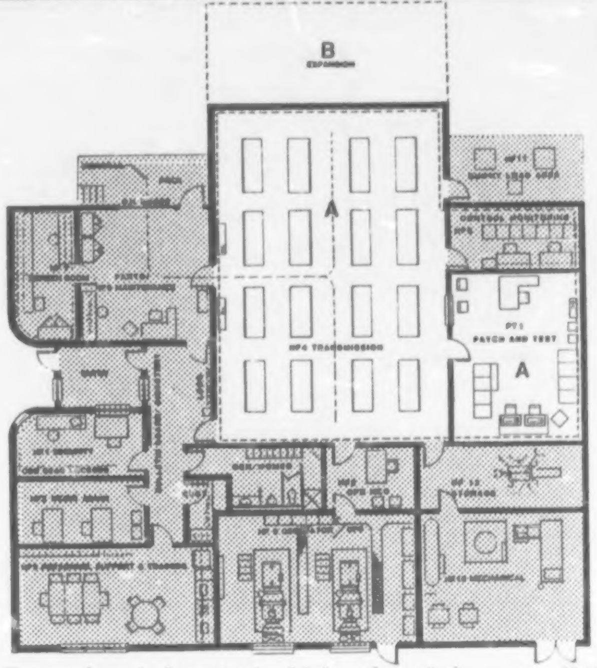
guidance 5. Integration of Power/UPS Modules



A. Modules that comprise the power and UPS gear should be contiguous and well integrated. Direct physical adjacencies provide economy by minimizing cable lengths and produce personnel efficiency through interaccess relationships.

B. Confining the power and UPS spaces to remote areas will minimize the impact of generator vibrations that could adversely affect the communications transmission.

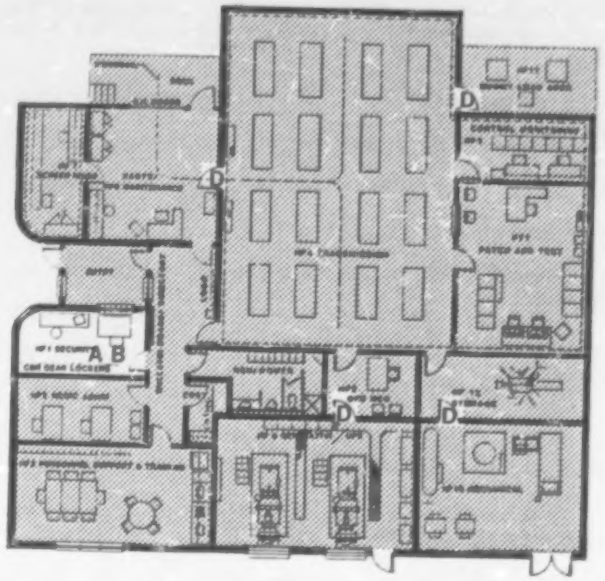
guidance 6. Facility Expansion



A. The equipment layout should be planned in a way that affords enough space for the installation of equipment capable of handling the maximum projected traffic load. The initial equipment layout should be such that the station facility's ultimate expansion can be done without extensive rearrangement of existing equipment.

B. Operations modules should be functionally isolated from support and power modules. Because of the increasingly rapid changes in communications technology, new demands on the spatial layout of operations modules can be expected in the future. Such spaces must be able to expand to accommodate new equipment and new functions. It is not anticipated that support and power spaces will need this same expansion capability and, therefore, may be located in their own areas; that is, facility design should allow operations modules to expand without greatly affecting the remaining functions.

guidance 7. Security Operation



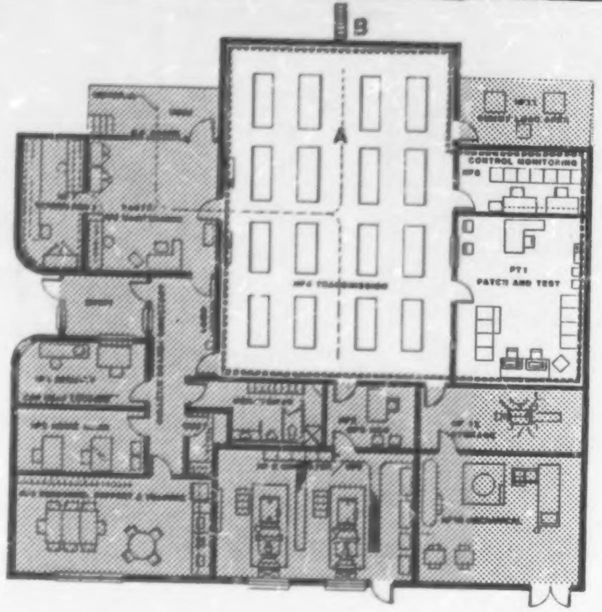
A. Security modules should be located to provide an overview for entry verification of visiting personnel. Additionally this module must be easily accessible to building occupants to facilitate efficient storage and distribution of weapons for personnel.

B. The security module will administer site security, monitor all intrusion detection systems, and initiate proper reactions to hostile threats. The security module should therefore be designed to provide overview and control over both site access and all exterior activities.

C. "Message" security is achieved by minimizing circulation between operations and cryptography modules, confining the modules to controlled areas, and providing disposal techniques to be performed or controlled by authorized personnel.

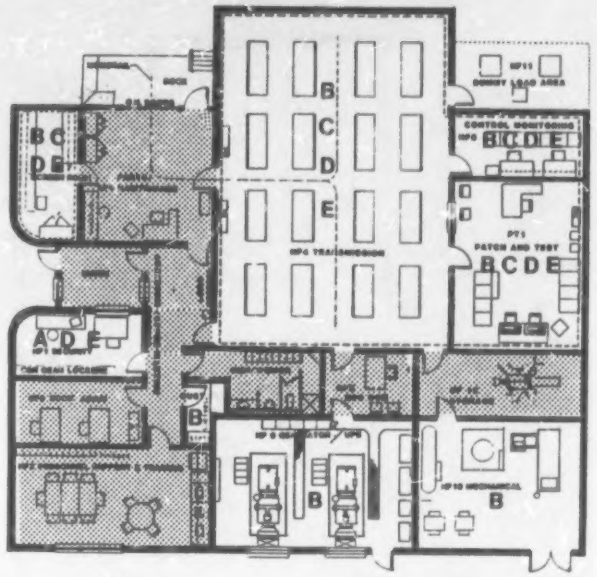
D. Required doors from other interior modules or from the outside that open into secure areas should have opening hardware only on the secure side.

guidance 8. Facility Security/Survivability



A. Conventional Class A vault construction is required for all spaces containing the communication system equipment--for example, operations, equipment, and tech control. Therefore, efficient construction methods and future building flexibility requirements can be met by locating these spaces in a contiguous relationship. These spaces usually require vault-type construction for a combination of four requirements: (1) HEMP protection, (2) TEMPEST shielding, (3) building intrusion resistance, and (4) fire protection. (See SB7, Security Systems--guidance for building security construction of Zone 4, Section 5b in Vol 2).

B. Communication facilities require waveguides in transporting the communications signal to and from the transmission/receiving equipment antennas. It is therefore necessary that the transmission/receiving module be located at a minimal distance from the antennas. In addition, waveguides must be physically protected to insure the facility's ability to perform its mission.



Occupancy classifications: Business (NFPA); B-2 (UBC)

Hazard of contents classification: Ordinary hazard

Sprinkler protection classification: Ordinary hazard--group 2.

Construction classifications/materials for fire protection (See Vol 2, the first figure in SB3, Fire Protection/Life Safety)

A. Type II--fire resistive (UBC) for security/armory spaces:

Construction Element	
Exterior walls	4-hour rated construction
Interior bearing walls	2-hour rated construction
Structural frame	2-hour rated construction
Permanent partitions	1-hour rated construction
Shaft enclosures	2-hour rated construction
Floors	2-hour rated construction
Roofs	2-hour rated construction

B. Type II--One-Hour (UBC) for battery, cryptography (RED/BLACK),* custodian, generator, operations,* mechanical, and transmission spaces:

All construction elements.......1-hour rated construction

Type II--N (UBC) for remainder of building spaces

All construction elements.......Noncombustible construction

Building Separation

Site-specific information is required. Comply with the second figure in Vol 2, SB3, Fire Protection/Life Safety.

Interior finishes

See Guidance/Life Safety, Vol 2.

Fire protection systems

Automatic fire suppression

A water sprinkler system shall be provided throughout the entire facility.

C. A Halon 1301 or carbon dioxide system shall be provided under raised floor areas containing nonmetallic, sheathed, exposed cables when the space under the raised floor is used as an air plenum.

Automatic notification/alarm

A general alarm must be activated by the automatic sprinkler system.

D. Local alarms are required to sound only in the designated spaces; they are activated by smoke detectors.

Automatic fire detection

E. Smoke detectors are required to activate local alarms only in the designated spaces. In rooms containing raised floor areas, smoke detectors shall be located under the raised floor.

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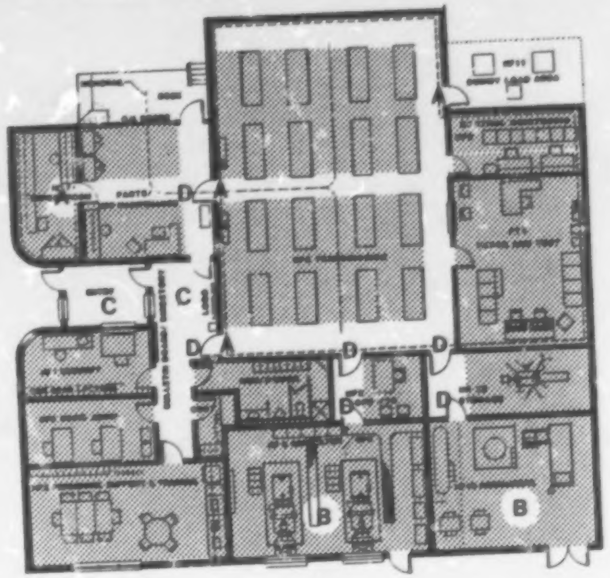
*See Vol 2, SB7, Security, for vault construction requirements that may be more stringent than those imposed by fire protection requirements.



OCCUPANT LOAD: (For determining exit requirements)

Occupant Load Factor: 100 sq. ft/person based on gross floor area (Business Occupancy-NFPA)

Occupant Load= (total facility)	$\frac{9{,}950 \text{ sq ft}}{100}$	=	100 persons
Occupant Load= (vaulted area)	$\frac{2{,}450 \text{ sq ft}}{100}$	=	25 persons
Occupant Load= (admin/support)	$\frac{1{,}450 \text{ sq ft}}{100}$	=	15 persons

Exit capacities

Corridors--100 persons per unit of exit width for travel in either direction. The minimum width of any exit access corridor or passageway shall be 44 inches in the clear.

Doors--100 persons per unit of exit width (a 3-foot door provides 1.5 units of exit width, providing an exit capacity for 150 persons).

Number of exits

No less than two exits shall be accessible from every part of every floor. One exit is permitted when the room or area has: (1) a total occupant load of less than 100 persons, (2) direct exit to an open area outside the building at the ground level, and (3) a total travel distance on the same level of not over 100 feet. (If stairs are involved, they shall be no more than 15 feet in height and shall be provided with complete enclosures to separate the stairs from any other part of the building.)

Exit travel distances

Required exits shall be located to allow access without passage through areas that may be locked. No dead end corridor shall exceed 50 feet. Travel distance to exits shall be no more than 300 feet when the building is protected throughout by an approved automatic sprinkler system.

Arrangement of means of egress

Exit access and travel routes to exits are shown in the plan.

A. Exit doors in vaulted areas that contain communications equipment are secured and permit egress out only. Exit access routes through vaulted areas from spaces outside the vaulted area are not permitted for security reasons.

B. Two means of egress shall be provided from higher hazard areas, including mechanical and generator spaces. Exit access from any other space may not pass through the mechanical or generator spaces (see exit marking). For security, when mechanical or generator spaces have exit access routes through interior spaces, exit access doors from these spaces, when opened, shall sound an alarm and transmit a signal to the annunciator panel in the security space. Access for normal maintenance in mechanical and generator spaces shall be through the exterior doors.

guidance

Interior finishes

C. Interior finish in exit access corridors shall be Class A only.

Interior finish in the remainder of the building shall be Class A or B only.

Means of egress lighting

Exits and exit access, including stairs, aisles, corridors, and passageways leading to an exit, shall be lighted continuously during times when the conditions of occupancy require means of egress to be available. Lighting should be no less than 1 footcandle measured at the floor.

Emergency lighting

Emergency lighting shall be provided in windowless buildings for designated aisles, corridors, and passageways leading to an exit. Emergency lighting shall stay at least 1 footcandle throughout the means of egress for 1.5 hours in the event of normal lighting failure.

Marking the means of egress

Exits shall be marked by an approved sign readily visible from any direction of exit access. Signs shall be placed such that no point in the exit access is more than 100 feet from the nearest visible sign.

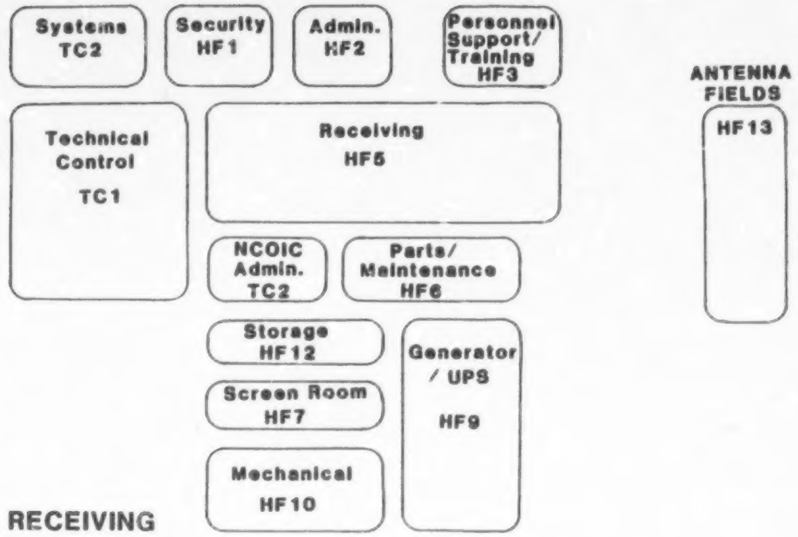
D. Doors located or arranged so that they are likely to be mistaken for exits shall be identified by a sign reading "NOT AN EXIT."

guidance

guidance

guidance

STANDARDIZED MODULES HF14


Systems
TC2
Security
HF1
Admin.
HF2
Personnel
Support/
Training
HF3
ANTENNA
FIELDS
HF13
Technical
Control
TC1
Receiving
HF5
NCOIC
Admin.
TC2
Parts/
Maintenance
HF6
Storage
HF12
Generator
/ UPS
HF9
Screen Room
HF7
Mechanical
HF10
RECEIVING

building design principles

1. Efficiency of operational functions
- a. Communication equipment aligned for surveillance and access.
- b. On-the-job training with operating equipment.
- c. Interaction of operational support activities.
- d. Accessibility of toilets for operations personnel.

2. Integration of parts/maintenance modules with operations
- a. Parts/maintenance modules contiguous with operations spaces.
- b. Loading dock accessibility for equipment and supplies.

3. Efficiency and accessibility of administration spaces
- a. Administration transition space between public areas and secure spaces.
- b. Efficiency of integrated administrative spaces.

4. Personnel support spaces
- a. Change of environment for on-duty personnel.
- b. Facilities available for physical training.

5. Integration of power/UPS modules
- a. Economies and efficiencies of integrated power modules.
- b. Minimized impact of generators on communications transmissions.

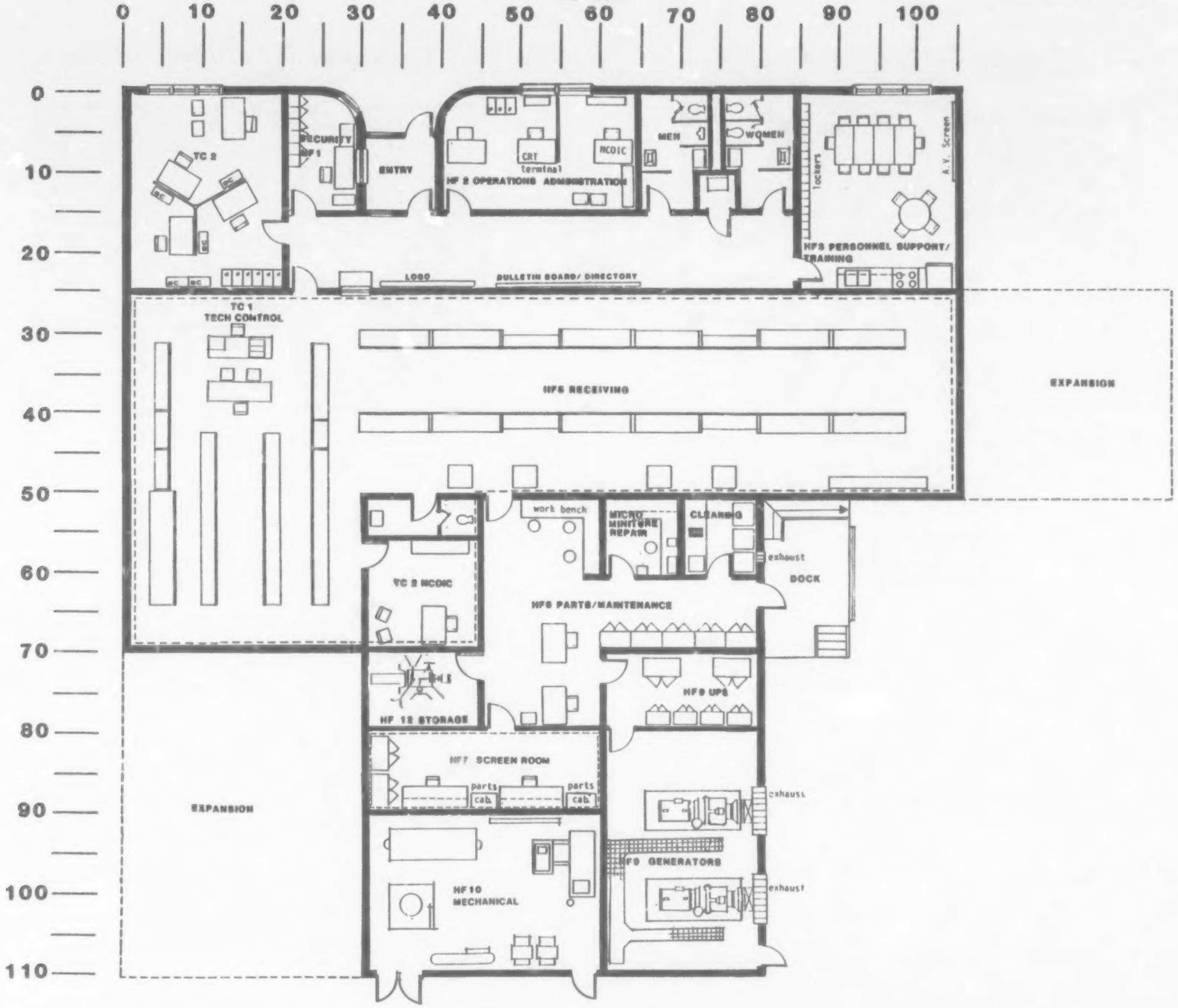
6. Facility expansion
- a. Expansion potential in new construction operations space.
- b. Minimized impact of future operations space expansion.

7. Security operation
- a. Location of security space to control building access.
- b. Central monitoring of total site and building security.
- c. Message security in operations and cryptography modules.
- d. Limited access into secure areas.

8. Facility security/survivability
- a. Required vault construction for communication system equipment.
- b. Protection of the communication signal.

9. Fire protection
- a. Fire protection classifications: occupancy, hazard of contents, sprinkler protection, and construction/materials.
- b. Building separation distances.
- c. Fire protection systems: automatic fire suppression, automatic notification/alarm, and automatic fire detection.

10. Life Safety
- a. Occupant load determination.
- b. Protected exit conditions: exit capacities, number of exits, exit travel distances, and means of exit arrangement.
- c. Allowable interior finishes.
- d. Egress path identification: illumination of means of egress, emergency lighting, and means of egress marking.


0
10
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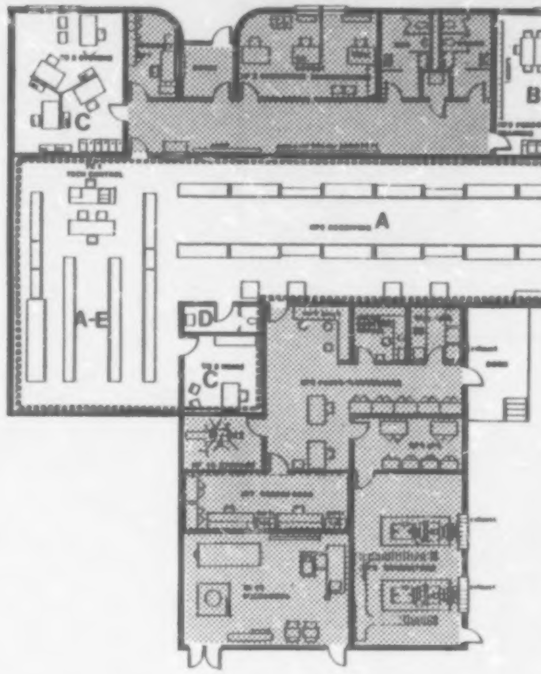
90
100
110
TC 2
SECURITY HF1
ENTRY
CRT terminal
NCOIC
HF 2 OPERATIONS ADMINISTRATION
MEN
WOMEN
lockers
A.V. Screen
HF3 PERSONNEL SUPPORT/ TRAINING
LOGO
BULLETIN BOARD/ DIRECTORY
TC 1 TECH CONTROL
HF5 RECEIVING
EXPANSION
work bench
MICRO MINITURE REPAIR
CLEANING
exhaust
DOCK
TC 2 NCOIC
HF6 PARTS/MAINTENANCE
HF 12 STORAGE
HF9 UPS
HF7 SCREEN ROOM
parts cab.
parts cab.
exhaust
HF8 GENERATORS
exhaust
HF10 MECHANICAL
EXPANSION

guidance 1. Efficiency of Operational Functions



A. Equipment should be aligned in parallel rows within the Operations modules for ease in visual surveillance and to provide direct access to all critical equipment. Multiple consoles should be adjacent to each other so that limited personnel may efficiently monitor them at one central location. Tables for AV training aids should be available in Operations modules so that personnel can train "on-the-job" during regular watch periods.

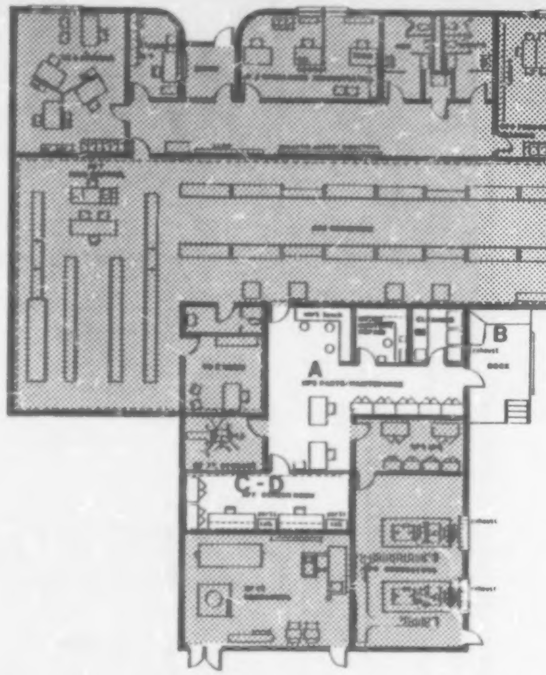
B. To further enhance the effectiveness of personnel training while "on-the-job", instruction may occur in small groups of 4 or 5 in a Training room for hands-on training working with the communications equipment, thus requiring a close relationship to the Operations module.

C. Additional building modules having a close functional relationship to Operations activities should be located adjacent to the Operations module.

D. Toilet facilities should be directly available for personnel in the Operations module.

E. See Technical Control module information in Section TC.

guidance 2. Integration of Parts/Maint. Modules with Ops.



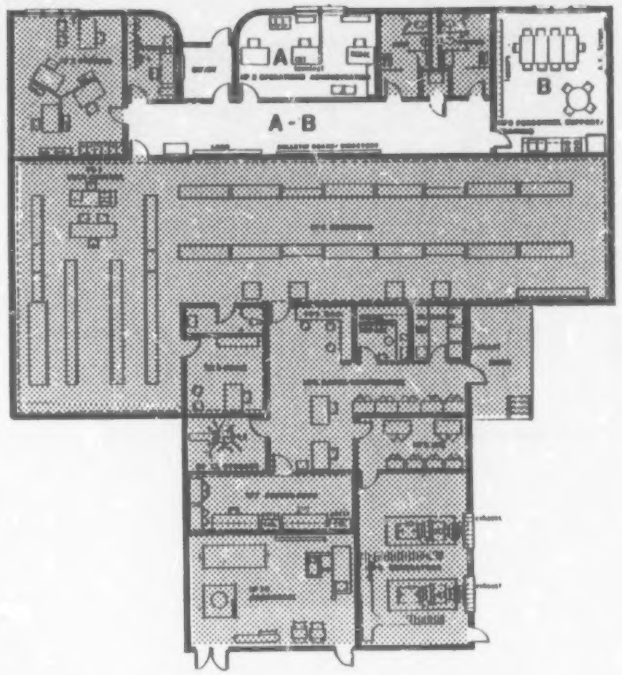
A. Parts and maintenance modules should be well integrated and contiguous to the operations spaces to optimize efficiency and minimize circulation. The secure door between the operations and the maintenance/parts spaces is only used as a fire exit and to bring communication equipment in and out via the loading dock. This door should have opening hardware only on the secure side.

B. Maintenance and Parts modules must be located within an organizational context such that deliveries can be made to the total building in a direct and secure manner at a loading dock. The large communication equipment can be more easily moved in and out using the loading dock. (Also, in multistory communication buildings, an elevator should be located adjacent to the Parts module in order to safely move large communication equipment vertically throughout the building.)

C Maintenance and screen room spaces should be both well integrated and contiguous to optimize efficiency of the maintenance function by minimizing circulation.

D Screen room must be isolated from radio frequency interference by location and construction.

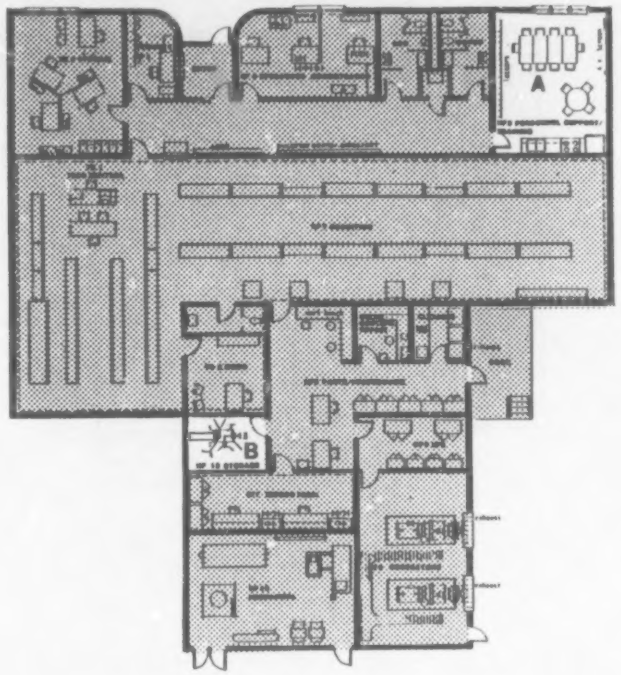
guidance 3. Efficiency and Accessibility of Admin. Spaces



A. Administration modules must be easily accessible to the public to minimize circulation and to prevent visitor interference with facility operations. The administration modules should provide a buffer and transition space between the exterior and interior secure spaces. Also, public corridors in the administration area should contain military unit logos and other display panels that relate to the "esprit de corps" and unit integrity of the communication station.

B. Administration spaces' integrated relationship will improve efficiency by minimizing public and administrative circulation and by producing a group adjacency to shared conference areas, secretaries, and waiting areas.

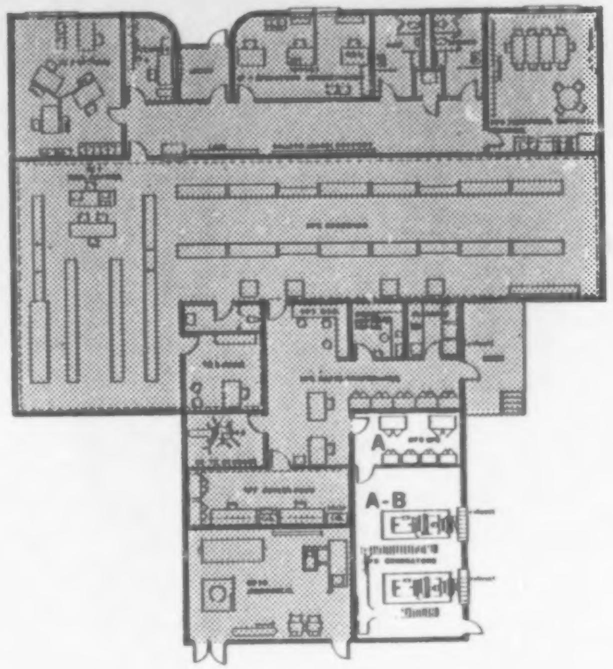
guidance 4. Personnel Support Spaces



A. The intense activities inside the DCS facility tend to generate mental fatigue among personnel. It is therefore necessary to create a change of environment for on-duty personnel to provide a break from the "hard surface" equipment room and work areas. The personnel support module should be directly adjacent to the operations room, but isolated acoustically and visually.

B. In addition, physical exercise equipment is recommended for DCS facilities located off military bases. The necessary showers and lockers should be similarly adjacent to the operations module for easy access and optimal use.

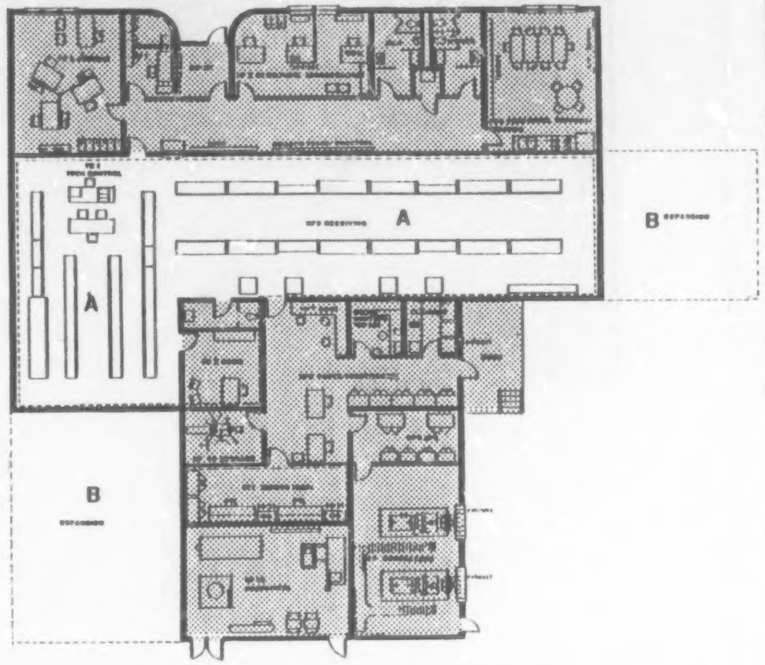
guidance 5. Integration of Power/UPS Modules



A. Modules that comprise the power and UPS gear should be contiguous and well integrated. Direct physical adjacencies provide economy by minimizing cable lengths and produce personnel efficiency through interaccess relationships.

B. Confining the power and UPS spaces to remote areas will minimize the impact of generator vibrations that could adversely affect the communications transmission.

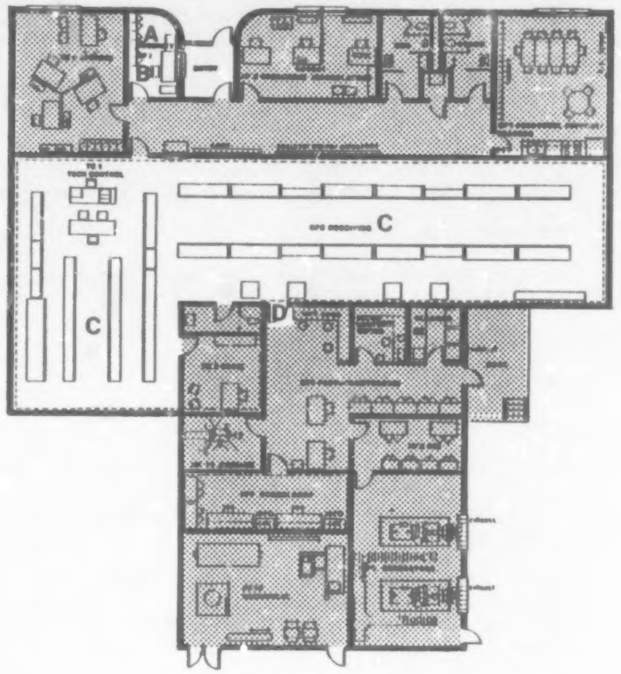
guidance 6. Facility Expansion



A. The equipment layout should be planned in a way that affords enough space for the installation of equipment capable of handling the maximum projected traffic load. The initial equipment layout should be such that the station facility's ultimate expansion can be done without extensive rearrangement of existing equipment.

B. Operations modules should be functionally isolated from support and power modules. Because of the increasingly rapid changes in communications technology, new demands on the spatial layout of operations modules can be expected in the future. Such spaces must be able to expand to accommodate new equipment and new functions. It is not anticipated that support and power spaces will need this same expansion capability and, therefore, may be located in their own areas; that is, facility design should allow operations modules to expand without greatly affecting the remaining functions.

guidance 7. Security Operation



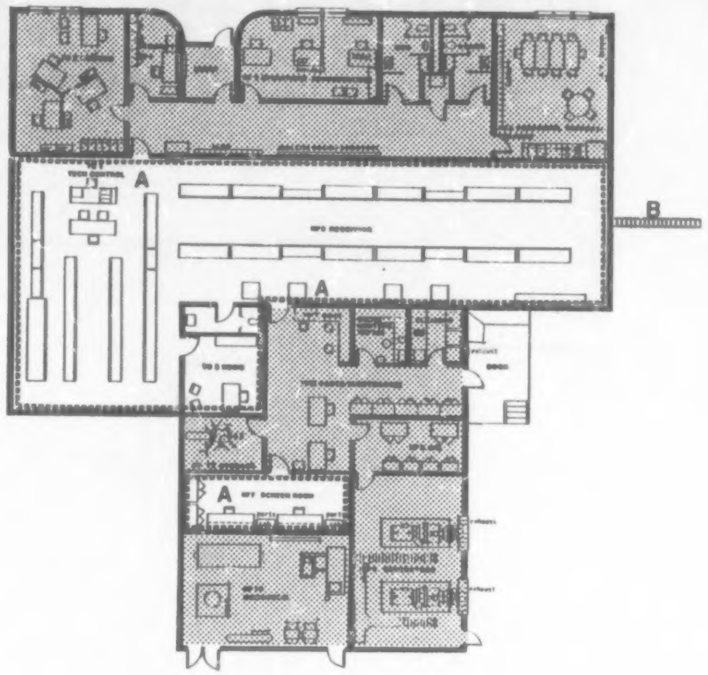
A. Security modules should be located to provide an overview for entry verification of visiting personnel. Additionally this module must be easily accessible to building occupants to facilitate efficient storage and distribution of weapons for personnel.

B. The security module will administer site security, monitor all intrusion detection systems, and initiate proper reactions to hostile threats. The security module should therefore be designed to provide overview and control over both site access and all exterior activities.

C. "Message" security is achieved by minimizing circulation between operations and cryptography modules, confining the modules to controlled areas, and providing disposal techniques to be performed or controlled by authorized personnel.

D. Required doors from other interior modules or from the outside that open into secure areas should have opening hardware only on the secure side.

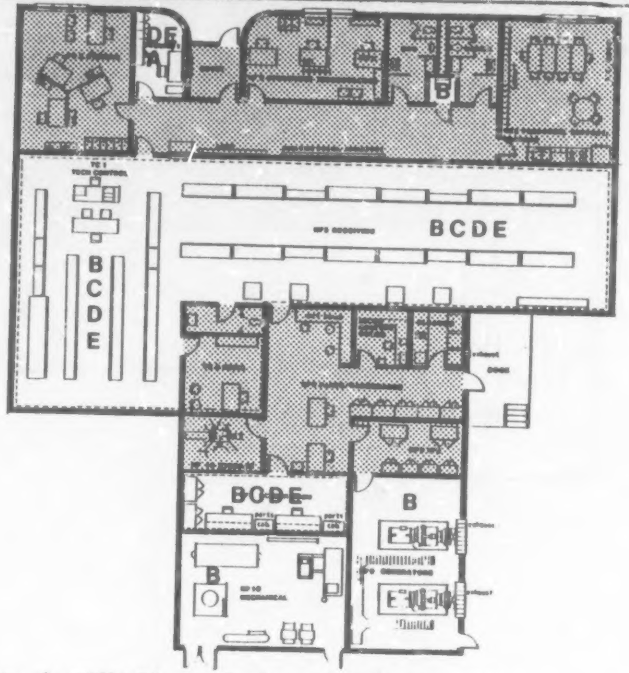
guidance 8. Facility Security/Survivability



A. Conventional Class A vault construction is required for all spaces containing the communication system equipment--for example, operations, equipment, and tech control. Therefore, efficient construction methods and future building flexibility requirements can be met by locating these spaces in a contiguous relationship. These spaces usually require vault-type construction for a combination of four requirements: (1) HEMP protection, (2) TEMPEST shielding, (3) building intrusion resistance, and (4) fire protection. (See SB7, Security Systems--guidance for building security construction of Zone 4, Section 5b in Vol 2).

B. Communication facilities require waveguides in transporting the communications signal to and from the transmission/receiving equipment antennas. It is therefore necessary that the transmission/receiving module be located at a minimal distance from the antennas. In addition, waveguides must be physically protected to insure the facility's ability to perform its mission.

guidance 9. Fire Protection



Occupancy classifications: Business (NFPA); B-2 (UBC)

Hazard of contents classification: Ordinary hazard

Sprinkler protection classification: Ordinary hazard--group 2.

Construction classifications/materials for fire protection (See Vol 2, the first figure in SB3, Fire Protection/Life Safety)

A. Type II--fire resistive (UBC) for security/armory spaces:

Construction Element	
Exterior walls	4-hour rated construction
Interior bearing walls	2-hour rated construction
Structural frame	2-hour rated construction
Permanent partitions	1-hour rated construction
Shaft enclosures	2-hour rated construction
Floors	2-hour rated construction
Roofs	2-hour rated construction

B. Type II--One-Hour (UBC) for battery, cryptography (RED/BLACK),* custodian, generator, operations,* mechanical, and transmission spaces:

All construction elements.......1-hour rated construction

Type II--N (UBC) for remainder of building spaces

All construction elements.......Noncombustible construction

Building Separation

Site-specific information is required. Comply with the second figure in Vol 2, SB3, Fire Protection/Life Safety.

.Interior finishes

See Guidance/Life Safety, Vol 2.

Fire protection systems

Automatic fire suppression

A water sprinkler system shall be provided throughout the entire facility.

C. A Halon 1301 or carbon dioxide system shall be provided under raised floor areas containing nonmetallic, sheathed, exposed cables when the space under the raised floor is used as an air plenum.

Automatic notification/alarm

A general alarm must be activated by the automatic sprinkler system.

D. Local alarms are required to sound only in the designated spaces; they are activated by smoke detectors.

Automatic fire detection

E. Smoke detectors are required to activate local alarms only in the designated spaces. In rooms containing raised floor areas, smoke detectors shall be located under the raised floor.

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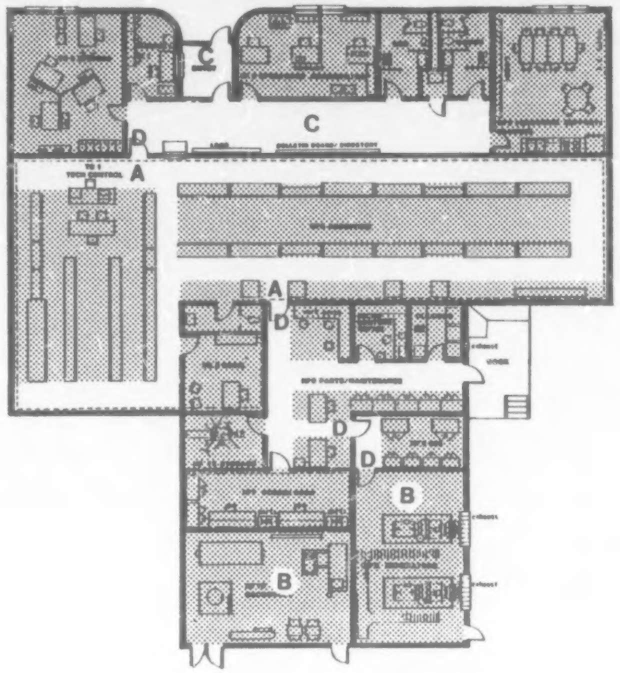
*See Vol 2, SB7, Security, for vault construction requirements that may be more stringent than those imposed by fire protection requirements.

guidance 10. Life Safety



OCCUPANT LOAD: (For determining exit requirements)

Occupant Load Factor: 100 sq. ft/person based on gross floor area (Business Occupancy-NFPA)

Occupant Load= (total facility) $\frac{8{,}750 \text{ sq ft}}{100}$ = 88 persons

Occupant Load= (vaulted area) $\frac{3{,}525 \text{ sq ft}}{100}$ = 36 persons

Occupant Load= (admin/support) $\frac{2{,}525 \text{ sq ft}}{100}$ = 26 persons

Exit capacities

Corridors--100 persons per unit of exit width for travel in either direction. The minimum width of any exit access corridor or passageway shall be 44 inches in the clear.

Doors--100 persons per unit of exit width (a 3-foot door provides 1.5 units of exit width, providing an exit capacity for 150 persons).

Number of exits

No less than two exits shall be accessible from every part of every floor. One exit is permitted when the room or area has: (1) a total occupant load of less than 100 persons, (2) direct exit to an open area outside the building at the ground level, and (3) a total travel distance on the same level of not over 100 feet. (If stairs are involved, they shall be no more than 15 feet in height and shall be provided with complete enclosures to separate the stairs from any other part of the building.)

Exit travel distances

Required exits shall be located to allow access without passage through areas that may be locked. No dead end corridor shall exceed 50 feet. Travel distance to exits shall be no more than 300 feet when the building is protected throughout by an approved automatic sprinkler system.

Arrangement of means of egress

Exit access and travel routes to exits are shown in the plan.

A. Exit doors in vaulted areas that contain communications equipment are secured and permit egress out only. Exit access routes through vaulted areas from spaces outside the vaulted area are not permitted for security reasons.

B. Two means of egress shall be provided from higher hazard areas, including mechanical and generator spaces. Exit access from any other space may not pass through the mechanical or generator spaces (see exit marking). For security, when mechanical or generator spaces have exit access routes through interior spaces, exit access doors from these spaces, when opened, shall sound an alarm and transmit a signal to the annunciator panel in the security space. Access for normal maintenance in mechanical and generator spaces shall be through the exterior doors.

guidance

Interior finishes

C. Interior finish in exit access corridors shall be Class A only.

Interior finish in the remainder of the building shall be Class A or B only.

Means of egress lighting

Exits and exit access, including stairs, aisles, corridors, and passageways leading to an exit, shall be lighted continuously during times when the conditions of occupancy require means of egress to be available. Lighting should be no less than 1 footcandle measured at the floor.

Emergency lighting

Emergency lighting shall be provided in windowless buildings for designated aisles, corridors, and passageways leading to an exit. Emergency lighting shall stay at least 1 footcandle throughout the means of egress for 1.5 hours in the event of normal lighting failure.

Marking the means of egress

Exits shall be marked by an approved sign readily visible from any direction of exit access. Signs shall be placed such that no point in the exit access is more than 100 feet from the nearest visible sign.

D. Doors located or arranged so that they are likely to be mistaken for exits shall be identified by a sign reading "NOT AN EXIT."

guidance

best copy available

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(Numerical)

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